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NEWFOUNDLAND SHELF SEA ICE PROGRAM, 1992

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TABLE OF CONTENTS

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ABSTRACT

Prinsenberg, S.J., I.K. Peterson and G.A. Fowler. 1993. Newfoundland Shelf Sea Ice Program, 1992. Can. Tech. Rep. Hydrogr. Ocean. Sci. 153:vi + 115 p.

Nineteen ice beacons, deployed on land-fast and mobile pack ice off the coast of Labrador and Newfoundland, were used to collect atmospheric, ice and oceanographic data during the winter of 1991-1992. The data were telemetered via satellite and used to study variations in sea ice properties in response to atmospheric and oceanographic conditions. This manuscript presents ice beacon, CTD and ice thickness data collected in the 1992 winter survey, as well as a preliminary analysis of the meteorological and ice conditions in 1992.

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Dix-neuf balises des glaces ont été déployées sur la banquise côtière et la banquise pour la collecte de données atmosphériques, glacielles et océanographiques au large de la côte du Labrador et de Terre-Neuve pendant l'hiver de 1991-1992. Les données ont été transmises par télémétrie par satellite et utilisées pour l'etude de variations des propriétés de la glace de mer en réponse aux conditions atmosphériques et océanographiques. Ce rapport présente les données provenant des balises des glaces, CTP et épaisseurs de glace pour le relevé de l'hiver 1992, ainsi qu'une analyse préliminaire des conditions meteorologiques et de glace pour l'hiver 1992.

TABLE CAPTIONS

Table 1. Areas, start and end times in 1992 calendar days, types and sensors (x) for ice beacons on both land-fast and drifting ice. Area numbers are 1 for Sandwich Bay near Cartwright (land-fast ice), 2 for Labrador pack ice and 3 for pack ice off Newfoundland. The times represent the times when the beacons were transmitting on the ice; in some cases, the sensors did not work over the whole period.

Table 2. Accuracy and resolution of ice beacon data parameters.

Table 3. Ice thicknesses from direct measurements and ice charts for February and March, 1992. Sizes of the floes on which the beacons were deployed are listed.

Table 4. Air temperature anomalies at stations along the Canadian east coast from "Climatic Perspectives" published monthly by AES (1992a).

Table 5. Monthly displacements of ice due to wind forcing. Monthly mean wind speeds for 16 directions were used, each an average over an 22.5° sector, multiplied by their frequency of occurrence and by 2.5% to convert wind speed to ice speed and turned 35° to the right of the wind to represent ice drift direction.

Table 6. Mean and standard deviation of velocity components, vector mean speed and direction, minimum and maximum daily speed and number of days for the 1992 ice beacons. U and V are the velocity components, such that positive U is toward the east, and positive V is toward the north.

Table 7. Salinity-Temperature profile data for 1992.

FIGURE CAPTIONS

Fig. 1. Ice chart of February 11, 1992, showing the locations of the beacons deployed on February 11 and 12. Hatched area nearshore represents landfast ice.

Fig. 2. Ice chart of March 7, 1992, showing the locations of the beacons deployed on March 6 and 8. Hatched areas nearshore represent landfast ice.

Fig. 3. Ice chart of March 17, 1992, showing the positions and 2-day displacements of the beacons deployed on March 16 and 17. Hatched areas nearshore represent landfast ice.

Fig. 4. Monthly contours representing the end points of 16 ice drift vectors in km/month for the 25-year mean and the 1990/91 and 1991/92 winters.

Fig. 5. Seasonal ice cover anomalies in $10^4 km^2$ (weekly values) for three areas along the Labrador/Newfoundland coast: Hamilton Bank area from 53 to $55^\circ N$, NE Newfoundland shelf from 49 to $51^\circ N$ and S Grand Bank from 45 to $47^\circ N$.

Fig. 6. Seasonal ice cover anomalies in $10^4 km^2$ (biweekly values) for three areas along the Labrador/Newfoundland coast for 1984 to 1992.

Fig. 7. Weekly mean ice extent with solid lines showing the 20-year mean, dashed lines the minimum and maximum ice extent in total 20-year records and dots the biweekly winter values of 1990/91 and 1991/1992.

Fig. 8. Trajectories of ice beacons deployed on February 11 and 12, with positions marked every 10 days.

Fig. 9. Trajectories of ice beacons deployed on March 6 and 8, with positions marked every 10 days.

Fig. 10. Trajectories of ice beacons deployed on March 16 and 17, with positions marked every 10 days.

Fig. 11. Air temperature and ice/water temperature profiles from ice beacon #10056, which was deployed on drifting ice off Cartwright on February 11. Dotted vertical lines represent freezing points ($-1.8^\circ C$) for the profiles, and 1 day=$1^\circ C$ in temperature.

Fig. 12. Stick plots of wind and ice velocity (3-hourly) from beacon #8667.

1.0 INTRODUCTION

The seasonal pack ice along the eastern Canadian seaboard poses a threat to safe operations at sea associated with hydrocarbon exploration, shipping and fishing. Sea ice programs of the Bedford Institute of Oceanography in Dartmouth, N.S. study the seasonal variability of the movement and extent of the pack ice along the Labrador and Newfoundland coasts to help in the safe management of offshore resources. Advection of ice by wind and ocean currents from the northern Labrador Shelf and Davis Strait is the major source of ice over the Northeast Newfoundland Shelf. This ice is thicker and takes longer to decay than the thinner locally-formed ice along the southern Labrador and Newfoundland Shelves. The southernmost extent of the pack ice is determined by a balance between the volume of ice advected southwards and the rate at which the ice is melted locally due to oceanic and atmospheric heat fluxes.

In recent years, field programs have collected ice, oceanic and atmospheric data to aid in the understanding of the processes controlling the movement and extent of the pack ice. During the winter of 1991/92, one field program deployed 16 ice beacons on land-fast and mobile pack ice off the Labrador coast, while a second program deployed three beacons on the mobile pack ice off the Newfoundland coast. After a description of the field programs and instrumentation, this manuscript presents the ice beacon, CTD and ice thickness data collected during the program as well as a preliminary analysis of the atmospheric data. Monthly anomalies of ice extent, air temperature and wind (the latter plotted as ice drift) for 1991/92 are discussed. The data collected by the program are shown in detail in the Appendices.

2.0 INSTRUMENTATION

2.1 ICE BEACONS

Five types of ice beacons, designed and manufactured by Metocean Data Systems Ltd. of Dartmouth, N.S., were deployed (Table 1). The beacons had a variety of sensor packages (Table 1), and the data were telemetered via the Argos satellite system. The position of each ice beacon is computed by Service Argos from the measured Doppler shift of the beacon transmissions, which are received for about 10 minutes on about 10 passes per day. The accuracy and resolution of the sensors of the beacons are listed in Table 2. Only the 4 beacons deployed on the landfast ice were recovered after the survey; the 15 deployed on the mobile pack ice by helicopter drifted freely with the pack ice until the floes on which they were deployed melted.

The main function of eight of the beacons was to collect position data from which ice drift rates were calculated. Four of the beacons were of the high Arctic version which float after the underlying ice melts and are capable of transmitting data for a one year period. In addition to position, they also report hull temperature, which is used to help determine when the underlying ice has melted. Four of the beacons were Compact Meteorological Ice Beacons (CMIB), which report barometric pressure, air temperature, and ice surface temperature and do not float. They have smaller battery packs designed to operate up to 3 months in marginal ice zone areas. One of the CMIBs was deployed off the Labrador coast and the other three off the Newfoundland coast.

Three beacons were equipped with R.M. Young anemometers, and a prototype beacon was equipped with a thrust anemometer; all four anemometers were positioned at a height of 2 m above the ice surface. The beacons compute a 10 minute average of wind speed and direction once per hour and transmit these 10 minute averages for each of the previous 6 hours, along with the barometric pressure and air temperature. Two of the R.M Young anemometer beacons were deployed on the offshore pack ice, while the other two anemometer beacons were deployed on landfast ice in Sandwich Bay near Cartwright, Labrador for engineering tests.

Two types of ice beacons provided temperature profiles in air, ice and water. Both used the basic CMIB as a data transmitter and as a platform to collect barometric pressure, and air and hull temperature. The first of these is the Small Ice Monitoring Platform (SIMP). It consists of the transmitter (CMIB) and a rigid temperature staff frozen into the ice through an augered ice hole. Eight air/snow thermistors are spaced 10cm apart above the ice surface, and 20 ice/water thermistors are spaced 5cm apart below the ice surface. The ice staff, containing the thermistors, is connected to the transmitter by an electrical cable. Three beacons of this type were deployed in the winter of 1991/1992, two on pack ice and one on landfast ice in Sandwich Bay.

The second beacon type measuring temperature profiles was a temperature chain ice beacon. It was either 50m or 100m long, and had a semi-rigid 2m top section which was frozen into the ice through an augered ice hole. Ice and surface water temperatures were collected by 6 temperature sensors spaced at 5, 20, 35, 50, 65 and 80cm below the snow/ice interface. The flexible chain consisted of a 1.0cm diameter cable along which temperature sensors were potted at (2, 3, 5, 10, 15, 20, 25, 30, 40, 50m) or (2, 3, 5, 10, 20, 30, 45, 60, 80 and 100m) below the snow/ice interface. A pressure sensor, mounted above the 50 lb ballast weight at the bottom of the chain, collected pressure data. The pressure data are used to determine the chain's wire angle from which the average current shear between the ice cover and the ocean surface layer can be obtained from mooring models (Hamilton, 1989).

2.2 TEMPERATURE-SALINITY INSTRUMENTATION

Temperature and salinity profiles were collected through augered ice holes at the sites where ice beacons were deployed, when time and weather permitted. The profiles were taken with a self-recording Seabird SBE-25 CTD probe. The CTD probe was lowered through augered ice holes by a cable fastened to a portable winch which was driven by the same auger gasoline engine used to drill the CTD ice holes. The accuracy/resolution of the sensors of the Seabird CTD are .004/.0003°C for temperature, .01/.005ppt for salinity and .25%/.015% for pressure.

Salinity samples of the ice were obtained from ice chips collected at various depths of the ice cover by the 4-inch hand-auger. The chips were stored and melted in standard sea water sample bottles. Salinity values were determined in the field with an AO-10419 hand-held refractometer which could be read to ±.5ppt. To check the accuracy of refractometer-determined values, salinity values of the samples were also determined by Guildline Autosal salinometer at the Bedford Institute of Oceanography.

3.0 STUDY AREA AND FIELD PROGRAM

The field programs deployed a total of 15 satellite-tracked ice beacons on the pack ice off the coast of Labrador and Newfoundland in order to study the response of ice drift and distribution to wind stress, air temperature and ocean currents. A detailed field schedule is given in Appendix A. For safety, two helicopters were used during the field trips. One helicopter carried up to eight ice beacons, while the second carried the augers, CTD system and the equipment for collecting ice salinity samples and ice thickness measurements. Helicopters were chartered from Universal Helicopter Ltd. and Canadian Helicopter Ltd.; both companies have helicopters stationed in Goose Bay.

On January 31, four beacons were deployed by snowmobile for test trials on landfast ice in Sandwich Bay near Cartwright, Labrador. The instruments were placed in an area where the water was deep enough to deploy the 50m temperature chain. A Small Ice Monitoring Platform (SIMP) beacon was placed alongside the temperature chain beacon to verify the ice temperature data collected by the chain. A prototype beacon equipped with a thrust anemometer was deployed alongside a standard beacon with a R.M. Young anemometer.

On February 11, 1992, three ice beacons were deployed on drifting pack ice off Cartwright (54°N) using two helicopters from Universal Helicopter Ltd. The ice chart for February 11 (Fig. 1) showed the ice cover extending south as far as the Grand Banks and east past the 1000m isobath, the median position of the eastern ice edge. The chart indicated that the three beacons deployed on February 11 were on pack ice with a concentration of $9^{+}/10$ and a maximum thickness ranging from 70-120cm offshore to 15-30cm inshore (Table 3). A position-only ice beacon was deployed at the outer site, a Temperature Chain ice beacon at the middle site, and a Small Ice Monitoring Platform (SIMP) at the inner site. Later in the day, the Sandwich Bay site near Cartwright was revisited to collect ice samples, ice thickness and snow depth measurements.

Three additional ice beacons were deployed off Cartwright on February 12 (Fig. 1) during low visibility and windy conditions. Stations were located closer to shore than planned, with the outer site only 40 miles offshore instead of the planned 60 miles. An anemometer beacon was deployed at the outer site, a Temperature Chain ice beacon at the middle site, and a location beacon at the inner site.

In early March, three beacons were deployed off the northern coast of Newfoundland (Fig. 2), as part of a second field program in which ice and snow thickness measurements were collected for comparison with SAR data from the ERS-1 satellite (Prinsenberg et al, 1993). Two beacons were deployed on March 6 and one on March 8. Their main purpose was to monitor ice drift, so that ice thickness measurements taken at different times could be realigned in space. Their secondary purpose was to provide additional data to describe the general behavior of the pack ice over the Labrador and Newfoundland shelves.

A set of six ice beacons was deployed by helicopter on March 16 and 17 (Fig. 3) after a delay of one day due to poor weather conditions. Ice had reached as far south as 46°, with heavy pack ice offshore of St. John's at 47.5° N. Off Cartwright, the pack ice covered the continental shelf with some thinner ice in the nearshore regions (Fig. 3). Previous storms had caused rafting of the pack ice, and floes were made up of several smaller floes with rafted rubble in between. Level floes large enough to land two helicopters (50x50m) were scarce. Three beacons were deployed on March 16 along a transect off Black Tickle (53.5°N). A position-only beacon was deployed at the offshore site 60 miles from the coast, a temperature chain beacon was deployed at the middle site and an atmospheric beacon at the inner site. Ice thicknesses were hard to obtain due to rafting conditions. Ice was rafted to over 2m at the offshore sites while at the inner site ice thicknesses between 130 and 165cm were observed.

On March 17, the three remaining ice beacons were deployed north off Cartwright, where again the pack ice consisted mostly of thick, rubbled pack ice. Inshore, thinner ice (54cm) was encountered. A position-only ice beacon was deployed at the outer site, a Small Ice Monitoring Platform (SIMP) at the middle site, and a Compact Meteorological Ice Beacon (CMIB) at the inner site. On the way back to Goose Bay, a site was visited off Long Point in Lake

Melville to measure water and ice salinity for future electromagnetic ice sounding work. The ice was difficult to drill since the salinity was only 3ppt. The ice thickness was 162cm, the snow layer 10cm and surface water salinity 3ppt.

4.0 1991/1992 ATMOSPHERIC AND ICE COVER ANOMALIES

4.1 AIR TEMPERATURES

As in the winter of 1990/91, below-normal air temperatures (Table 4) and above-normal ice extent were experienced along the Canadian east coast during the winter of 1991/92. Before January, air temperatures were normal throughout the area. However, for the January to March period (when each year the southern edge of the pack ice advances southward), air temperatures in 1992 were 3.3°C below normal; even colder than in the previous winter. This increased the ice growth throughout the area and decreased the ice melt rates along the advancing ice edge. The ice extent at the end of January was 2 to 4 weeks ahead of normal conditions, as was the ice extent in 1990/91 (February 3-9, 1992 Climatic Perspectives). For the April to June period (when each year the southern ice edge retreats northward), air temperatures in 1992 were 2.4°C below normal, with the greatest temperature anomaly in the Hudson Strait/southern Davis Strait area. This region is a source for the heavy pack ice which advances the farthest south during the ice season.

4.2 WIND-DRIVEN ICE DRIFT

Northwesterly winds from the Arctic not only bring cold air causing ice growth along the Labrador and Newfoundland coasts but are also the major contributor to the southward drift of pack ice. Monthly surface wind histograms can be used to estimate monthly ice displacements assuming free ice-drift at 2.5% of the wind speed and 35° to the right of the wind (Peterson and Prinsenberg, 1989). For 25-year mean winds (1955-1980), the distances the ice drifted per month due to wind forcing in 16 directions (22.5° sections) are shown in Figure 4. For each month, the figure shows the contour made by joining the 16 vector end points. These 16 displacement vectors can be vectorially added to provide a net displacement per month (Table 5). Under normal conditions ice is advected over the Newfoundland shelf at 145 km/month by the wind towards the southeast in winter (Jan-Mar) and at 90km/month towards the south-southeast in the spring (Apr-Jun). For the southern Labrador coast, the ice is advected at 170 km/month to the southeast in winter. For this case, the direction appears to be bimodal; to the northeast (offshore) and to the south (alongshore). In the spring, ice is advected primarily to the south but at a reduced rate of 100km/month.

As was the case in the previous winter, winds and inferred ice displacements in 1991/92 (Fig. 4), were higher than the 1955-1980 means (Table 5). For the January to March period, winds and inferred ice drifts were 25% stronger over the Newfoundland Shelf and 45% over the southern Labrador Shelf (the pack ice drifted 100km farther south than normal over the Newfoundland Shelf and 240km farther south over the Labrador Shelf). However, the winds and thus the inferred ice drifts (Table 5) were not as large as those which occurred during the same period in the 1990/91 winter.

Although winds at Cartwright were stronger than normal during December and January, they had a large southwesterly component which pushed ice offshore into the Labrador Sea (Fig. 4). During February and March, winds at Cartwright were from the north (as normal), and were strong. However, winds were normal in April and May. At Gander in March, instead of the usually gentle bimodal NW and N winds, extremely strong NW winds occurred, which would have resulted in a larger offshore drift than normal. In April, winds at Gander still had a strong NW component, characteristic of winter conditions.

In summary, winter winds were stronger and had larger offshore components than normal while the gentler spring winds were late in arriving to the area by about a month.

4.3 ICE COVER

The anomalies of the ice cover extent (Figs. 5 and 6) show that 1991/92 ice extent was as severe as that of 1990/91 (Prinsenberg and Peterson, 1992) in the early part of the winter but did not persist as long in the spring. The December ice coverage in the Hamilton Bank region was twice its normal extent, as was the January ice extent in the NE Newfoundland Shelf region (Fig. 7). In February and March, the ice extent in all three regions was above normal and the year's maximum ice extent was reached earlier. The rate of decrease in ice extent over the NE Newfoundland Shelf area was normal but delayed by two weeks. The decay rate over Hamilton Bank and S. Grand Bank at the end of the ice season was faster but the time of ice disappearance was normal for the two areas.

The ice conditions in 1992 can be explained by the wind and air temperature anomalies. In December, air temperatures were below normal due to increased northwesterly airflow from the Arctic. The cold air decreased ice melt at the ice edge, and the ice edge moved southwards faster than normal due to the increase in wind strength. In 1991/92 a larger offshore wind component existed over the Newfoundland Shelf area than in 1990/91. This caused melting of the thicker pack ice found offshore, while in the inshore regions, thin ice was formed. However, the total surface area covered by the pack ice was similar in the two years with slightly less areal extent in 1991/92. In 1990/91 the ice was rafted against the shore by onshore winds, decreasing the ice extent to below normal in March, while in 1991/92 offshore winds decreased the ice extent. In both years the air temperatures were below normal during the period of January to March. This increased the local ice growth in areas having thin ice and open water and decreased ice melt at the advancing ice edge.

During the ice retreat period of April to June, air temperatures for 1991/92 were below normal (-0.9°C) over the southern Labrador and Newfoundland shelves but not as cold as during the same period in 1990/91 (-1.8°C). Winds off Newfoundland during both years had a lower offshore component than normal, decreasing the ice flux to the open ocean. The pack ice retreated at a normal rate in 1991/92 but generally was late by 2 weeks. It retreated faster than in 1990/91, since it was not as severely rafted by onshore winds, and ice thicknesses would therefore be lower.

5.0 ICE BEACON DATA

5.1 ICE BEACON TRAJECTORIES

The start and end times of the period over which the ice beacons operated on the ice are shown in Table 1. The operating period ranged from less than one day to 60 days, with a mean of 35 days for the beacons on the drifting pack ice. The four beacons on landfast ice were field-tested for 45 days.

After removing spikes from the positon data, 6-hourly values were computed using linear interpolation. The trajectories of the beacons for the three deployments, based on these 6-hourly positions, are plotted in Figures 8, 9 and 10. The trajectories of individual beacons are shown in Appendix B, with the positions marked at 1800 GMT each day and labelled every 10 days. The beacons deployed in February off Cartwright followed an cohesive drift pattern southward and parallel to the coast in the channel located on the inner shelf between Hamilton Bank and the Labrador Coast (Fig. 8). Their mean speed over the first two weeks was 18km/day, mostly in response to the stronger northwesterly winds (Table 5). By early March, under increased westerly winds, the beacons moved southeastward over the NE Newfoundland shelf towards the shelf break where by mid-March the warmer offshore water melted the ice on which they were deployed.

The beacons deployed in March off Newfoundland moved eastward for three weeks before drifting to the southwest for the next 10 days. This large easterly displacement was the result of the unusual strong westerly to northwesterly winds and is plotted as ice drift in Figure 4. After the end of March, the drift of the beacons was towards the southeast and southwest, more normal for the area under the bimodal direction of the spring winds coming from the northwest and northeast.

The beacons deployed in March off Cartwright followed two different drift patterns (Fig. 10). During the first two weeks, one group of three beacons drifted southward over the inner shelf similar to the beacons deployed in February but at a slower rate of 14 km/day. The other three beacons were stalled first over Hamilton Bank before moving slowly southward at 5km/day. Over the Newfoundland Shelf, the five remaining beacons drifted southward over the inner shelf before the ice melted beneath them.

Daily mean velocity components were calculated from beacon positions using 2100 GMT as start and end times. For each beacon, Table 6 lists the mean velocity components, mean speed and direction travelled as well as minimum and maximum daily speeds over the period the beacons tracked the offshore pack ice. Beacons drifted from 9cm/sec to 23cm/sec towards the south and southeast. Daily speeds were as high as 76cm/sec or 66 km for a single day.

5.2 ICE BEACON ENVIRONMENTAL DATA

In addition to position data, the beacons collected data from the ocean, ice cover and atmosphere. A list of sensors on the various ice beacons is shown in Table 1.

All the data except wind data were processed as follows. For each pass, the median value for each parameter was computed and obvious spikes were removed. Most of the data are plotted in Appendix C. Hourly ice and water temperatures were computed using linear interpolation and used to derive daily mean profiles. Air temperature and the ice and water temperature profiles for beacon 10056 are shown in Figure 11 as an example, with the complete set of profiles (beacons 1052, 1056, 1057, 10053, 10054, 10055, and 10056) plotted in Appendix C. The ice and water temperature profiles are plotted as solid lines every 2 days relative to -1.8°C lines which are dotted, and 1 day represents 1°C.

Of the three ice temperature profile ice beacons (SIMPs) deployed (#1052, #1056, and #1057), the beacon on landfast ice in Sandwich Bay (#1056) operated for 45 days until it was recovered, and the beacons on drifting ice (#1052 and #1057) operated for 25 and 43 days respectively. The four ice beacons with thermistor chains (#10053, #10054, #10055, and #10056) operated for 33, 30, 33 and 33 days respectively, until the battery voltage dropped too low. For the beacon with the 50m chain in Sandwich Bay (#10055), at least half of the 10 water temperature sensors appeared to be faulty. For one of the 100m thermistor chain beacons on drifting ice, #10054, the ice and water temperature sensors became faulty after 13 days.

Of the 3 beacons deployed with R.M Young anemometers, #4757 transmitted very intermittently, and #8663 transmitted for less than one day. For the remaining beacon, #8667, the hourly wind data were sorted using the internal clock time. For each hour, the record having the largest number of repeats was selected. Missing values were filled using linear interpolation. Three-hourly mean wind components are shown as stick plots in Figure 12 along with the 3-hourly drift velocities of the floe the beacon was on. The data cover a 57-day period during which the ice floe moved southwards a total of 570km, reaching as far south as Bonavista Bay, where it turned eastward and fell in the water on day 132. It continued to transmit for another 9 days as it drifted eastward. Fig. 12 shows a high correlation between the wind and beacon drift.

5.3 ICE AND WATER TEMPERATURE/SALINITY DATA

Ice salinity samples and CTD profiles were collected at landfast and pack ice beacon deployment sites when weather and time permitted. Twelve CTD profiles (Appendix E) and fourteen ice salinity profiles (Appendix D) were taken. Another two salinity ice profiles were taken from the mobile pack ice off Newfoundland and are listed in Prinsenberg et al., 1993.

The CTD data were averaged in 0.5 dbar bins, and are shown as plots in Appendix E for both the downcasts (solid lines) and upcasts (dashed lines). Freezing temperatures, also shown, were calculated as a function of salinity and pressure using the equations of Fujino et al (1974). The CTD data listed at intervals of 5dbar (Appendix E) are from the upcast for all stations except PRINS100 and PRINS101.

In February, the CTD profiles at the deployment sites showed that the depth of the homogeneous surface mixed layer was 150m, the final depths of two of the profiles. Below this depth the temperature showed a slight increase to 170m at the first CTD site (Sta. 9203). In March salinities and temperatures varied more with depth. On March 16, the homogeneous surface layer with temperature near the freezing point extended to only 35m at the outer station, increasing in depth to 40m at the middle and to 65m at the inner station. At the outer two stations, temperatures increased rapidly with depth to above 0.0°C below 130m.

Salinity samples from the ice cover were obtained by collecting and melting ice chips in standard sea water bottles. The salinity values were determined in the field with a refractometer, while a representative number of samples were brought back to the Institute for verification of the refractometer determined salinities using the Autosal salinometer. Comparison of salinity values determined by both the refractometer and Autosal salinometer showed, as in past surveys, that the refractometer provides salinity values with accuracies to ±.5ppt: an adequate accuracy for sea ice research as ice salinities vary that much over distances of less than one meter. Six ice salinity samples from the landfast ice station in Sandwich Bay had a mean value of 8.5ppt with higher values at the top of the ice column.

Ice salinities from the mobile pack ice of Labrador coast ranged from 2.0 to 37.0 ppt with a mean of 10.7ppt for the 42 samples collected in 1992. The lowest value (2.0 ppt) was probably refrozen snow, while the highest value (37.0 ppt) probably contained an unusual number of brine pockets. If these two values are neglected, the mean ice salinity is 10.3 ppt. The remaining 40 salinityvalues ranged from 5.5 ppt to 27.0 ppt with the highest values in each profile generally occurring at the bottom of the ice column.

6.0 CONCLUSION

Below normal air temperatures and stronger than normal northwesterly winds caused severe ice conditions during the winter of 1991/1992 over the Labrador and NE Newfoundland shelves. The ice cover appeared earlier, was larger in areal extent and retreated later than normal. Ice conditions were not as severe in coastal areas as in the previous year since the above normal offshore winds continued to clear coastal areas of ice.

During the winter of 1992, the Bedford Institute of Oceanography deployed a total of 19 satellite-tracked ice beacons off the Labrador coast, 15 on drifting pack ice and 4 on landfast ice. Several different types of ice beacons were used, all of which telemetered their environmental data via the Argos satellite system and provided position data. The first set of six beacons deployed in February drifted quickly southwards at 18km/day before crossing the Newfoundland Shelf towards the shelf break where the pack ice melted in the warm offshore water. The second set of six beacons drifted southwards as well but at slower speeds of 5 to 14km/day in part due to the reduced wind strength that occurs in the spring months.

Temperature and salinity profiles of the water column beneath the ice cover were collected at eleven of the beacon deployment sites and at a single station in Melville Lake. In February, there was a homogeneous layer of water at the freezing point of sea water down to 150m with warmer saltier water below it offshore. In March, the homogeneous surface layer was much shallower. It ranged from 35m at the offshore stations to 65m at the nearshore stations. Water temperatures rapidly increased to above $0^{\circ}C$ below 130m.

ACKNOWLEDGEMENT

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Table 1. Areas, start and end times in 1992 calendar days, types and sensors (x) for ice beacons on both land-fast and drifting ice. Area numbers are 1 for Sandwich Bay near Cartwright (land-fast ice), 2 for Labrador pack ice and 3 for pack ice off Newfoundland. The times represent the times when the beacons were transmitting on the ice; in some cases, the sensors did not work over the whole period.

Area	Beacon ID	Type*	Year Day Start	Year Day End	Sensors: Bar. P.	Air T.	Hull T.	Ice T.	Wind
1	4757	Anem.	31	65	x	x	-	-	x
1	3326	Anem.	31	65	-	-	-	-	x
1	1056	SIMP	31	76	x	x	x	x	-
1	10055	T.C.	31	64	x	x	x	x	-
2	10056	T.C.	42	75	x	x	x	x	-
2	1057	SIMP	42	85	x	x	x	x	-
2	3320	Loc.+	42	77	-	-	x	-	-
2	10054	T.C.	43	73	x	x	x	x	-
2	3321	Loc.+	43	88	-	-	x	-	-
2	8663	Anem.	43	43	x	x	-	-	x
3	4758	CMIB	66	96	x	x	x	-	-
3	4760	CMIB	66	111	x	x	x	-	-
3	4759	CMIB	68	103	x	x	x	-	-
2	8647	Loc.+	76	115	-	-	x	-	-
2	8667	Anem.	76	133	x	x	-	-	x
2	10053	T.C.	76	109	x	x	x	x	-
2	4763	CMIB	77	92	x	x	x	-	-
2	1052	SIMP	77	102	x	x	x	x	-
2	8649	Loc.+	77	137	-	-	x	-	-

* Anem. = Anemometer beacon
CMIB = Compact Meteorological Ice Beacon
Loc.+ = Location (plus hull temperature) beacon
SIMP = Small Ice Monitoring Platform
T.C. = Temperature Chain Beacon

Table 2. Accuracy and resolution of ice beacon data parameters.

Data parameters	Accuracy	Resolution
Latitude	0.2 km	0.1 km
Longitude	0.2 km	0.1 km
Barometric pressure	1.5 mb	0.15 mb
Air temperature	1.0°C	0.3°C
Hull temperature	1.0°C	0.2°C
Ice temperature		
#1052-1057	1.0°C	0.1°C
#10053-10056	1.0°C	0.2°C
Water temperatures	1.0°C	0.1°C
Wind: speed (<10 m/s)	1.0 m/s	0.48 m/s
speed (>10 m/s)	10%	10%
Wind direction	5°	<1°

Table 3. Ice thicknesses from direct measurements and ice charts for February and March, 1992. Sizes of the floes on which the beacons were deployed are listed.

	OBSERVED				ICE CHART		
Date	Stn. #	Thick-ness cm	Floe size mxm	Snow cm	Type	Thick-ness cm	Conc. %
Feb. 11							
	9202	200+	75x75	19	1.	70-120	10
	9203	160	75x75	21	7	30-70	80
	9204	220+	40x50	19	5	15-30	10
Feb. 12							
					1.	70-120	10
	9205	160	40x60	9	7	30-70	80
	9206	280	40x50	24	5	15-30	10
					7	30-70	60
	9207	200+	50x75	4	5	15-30	30
Mar. 6							
	PI#1	95	50x50	4	4.	120+	30
	PI#2	95	50x50	4	1.	70-120	40
Mar. 8	PI#3	49	130x150	2	7	30-70	30
Mar. 16							
	9208	210	40x60	0	4.	>120	20
	9209	240+	50x50	4	1.	70-120	40
	9210	165	50x50	10	7	30-70	30
Mar. 17							
	9211	130	50x50	5	4.	>120	10
	9212	142	50x30	3	1.	70-120	30
	9213	54	200x200	2	7	30-70	60

Table 4. Air temperature anomalies at stations along the Canadian east coast from "Climatic Perspectives" published monthly by AES (1992a).

WINTER 1991-1992 AIR TEMPERATURE ANOMALIES (°C)

AREA	Baffin Bay	Davis Strait	Hudson Strait	Labrador S. Coast	Newfoundland NE. Coast	
Station	Clyde	C. Dyer	Iqaluit	Cartwright	St. John's	
October	-0.9	-0.9	-0.0	0.8	0.7	
November	0.6	2.6	3.2	0.6	0.8	
December	-1.8	-1.6	-0.1	-5.6	-2.2	
January	-3.2	0.0	0.2	-2.0	-2.8	
February	-6.6	-7.5	-7.5	-6.5	-2.1	
March	-2.5	1.0	-5.0	-2.0	-3.1	
April	-2.0	-3.6	-4.9	-2.4	-2.1	
May	-4.4	-5.1	-5.1	-1.8	0.8	
June	-1.0	-1.8	-2.8	0.1	0.0	
						Total Area
Jan.-Mar.92	-4.1	-2.2	-4.1	-3.5	-2.7	-3.3
Apr.-Jun.92	-2.5	-3.5	-4.3	-1.4	-0.4	-2.4

						Total Area
Jan.-Mar.91	-2.2	-2.9	-3.1	-2.7	-1.6	-2.5
Apr.-Jun.91	1.4	-1.1	-1.5	-2.4	-1.2	-1.0

Table 5. Monthly displacements of ice due to wind forcing. Monthly mean wind speeds for 16 directions were used, each an average over an 22.5° sector, multiplied by their frequency of occurrence and by 2.5% to convert wind speed to ice speed and turned 35° to the right of the wind to represent ice drift direction.

	NE. NEWFOUNDLAND SHELF (GANDER WIND)				S. LABRADOR SHELF (CARTWRIGHT WIND)			
	1955-1980		1991/1992		1955-1980		1991/1992	
MONTH	DIST. (KM)	DIR. (DEG)	DIST. (KM)	DIR. (DEG)	DIST. (KM)	DIR. (DEG)	DIST. (KM)	DIR. (DEG)
NOV.	140	100	105	135	170	120	220	145
DEC.	180	105	205	110	190	125	320	105
JAN.	170	115	200	105	170	125	245	110
FEB.	155	125	130	155	165	130	280	145
MAR.	115	140	250	90	170	150	250	140
APR.	95	150	80	130	140	180	195	190
MAY	65	125	70	155	110	185	115	155
JUN.	120	75	35	145	50	150	40	205
JAN-MAR	145	125	180	110	170	135	250	140
APR-JUN	90	115	60	140	100	170	110	180

1955-80 winds are from "Canadian Climate Normals" (AES, 1982).
1990-91 winds are from "Monthly Records" (AES, 1992b)

	1955-1980		1990/1991		1955-1980		1990/1991	
MONTH	DIST. (KM)	DIR. (DEG)	DIST. (KM)	DIR. (DEG)	DIST. (KM)	DIR. (DEG)	DIST. (KM)	DIR. (DEG)
NOV.	140	100	170	115	170	120	315	195
DEC.	180	105	220	95	190	125	280	115
JAN.	170	115	280	120	170	125	280	125
FEB.	155	125	210	115	165	130	240	125
MAR.	115	140	115	210	170	150	140	190
APR.	95	150	100	195	140	180	190	175
MAY	65	125	95	135	110	185	170	190
JUN.	120	75	50	125	50	150	210	200
JAN-MAR	145	125	200	145	170	135	265	145
APR-JUN	90	115	80	155	100	170	190	190

Table 6. Mean and standard deviation of velocity components, vector mean speed and direction, minimum and maximum daily speed and number of days for the 1992 ice beacons. U and V are the velocity components, such that positive U is toward the east, and positive V is toward the north.

Beacon ID	$\bar{U}$ cm/s	s.d.(U) cm/s	$\bar{V}$ cm/s	s.d.(V) cm/s	Speed cm/s	Dir. °T	Min Sp. cm/s	Max Sp. cm/s	Days
01052	7.5	17.9	-18.9	22.3	20.4	158.	2.7	74.3	25
01057	13.1	14.9	-13.0	15.8	18.4	135.	7.7	69.6	42
03320	17.0	14.2	-16.0	18.1	23.3	133.	4.3	75.6	34
03321	13.6	15.1	-12.9	15.9	18.7	133.	2.5	63.0	40
04758	11.1	12.1	-5.2	15.3	12.3	115.	4.9	49.1	29
04759	7.4	16.4	-4.4	15.6	8.6	121.	9.2	56.8	34
04760	10.8	18.9	-8.3	16.3	13.6	128.	4.4	65.9	45
04763	4.3	9.4	-15.3	17.7	15.9	164.	2.1	48.4	14
08647	10.6	18.0	-16.5	23.4	19.6	147.	3.7	67.8	39
08649	3.9	13.7	-10.4	21.4	11.1	159.	1.8	72.7	59
08667	3.8	13.3	-10.8	18.3	11.5	161.	2.3	75.1	56
10053	6.1	19.9	-10.2	21.1	11.9	149.	3.4	65.7	33
10054	15.0	13.9	-17.3	12.2	22.9	139.	9.0	69.6	30
10056	14.1	13.1	-18.0	13.9	22.8	142.	4.9	65.7	32

Table 7. Salinity-Temperature profile data for 1992.

Stn #	File #	Temperature		Salinity		Depth (m)	
		down	up	down	up	mixed l.	profile
9203	PRINS100	yes	no	no	no	150	170
9204	PRINS101	yes	no	20m	no	150	150
9205	PRINS102	yes	yes	yes	yes	145	145
9207	PRINS103	no	yes	no	no	90	90
9208	CART9200	yes	yes	yes	yes	30	150
9209	CART9201	yes	yes	40m	yes	40	150
9210	CART9202	yes	yes	30m	yes	60	150
9201	CART9203	yes	yes	yes	yes	0	35
9211	CART9204	yes	yes	no	yes	55	150
9212	CART9205	yes	yes	30m	yes	120	150
9213	CART9206	yes	yes	no	yes	60	60
9214	CART9207	yes	yes	yes	yes	2	30

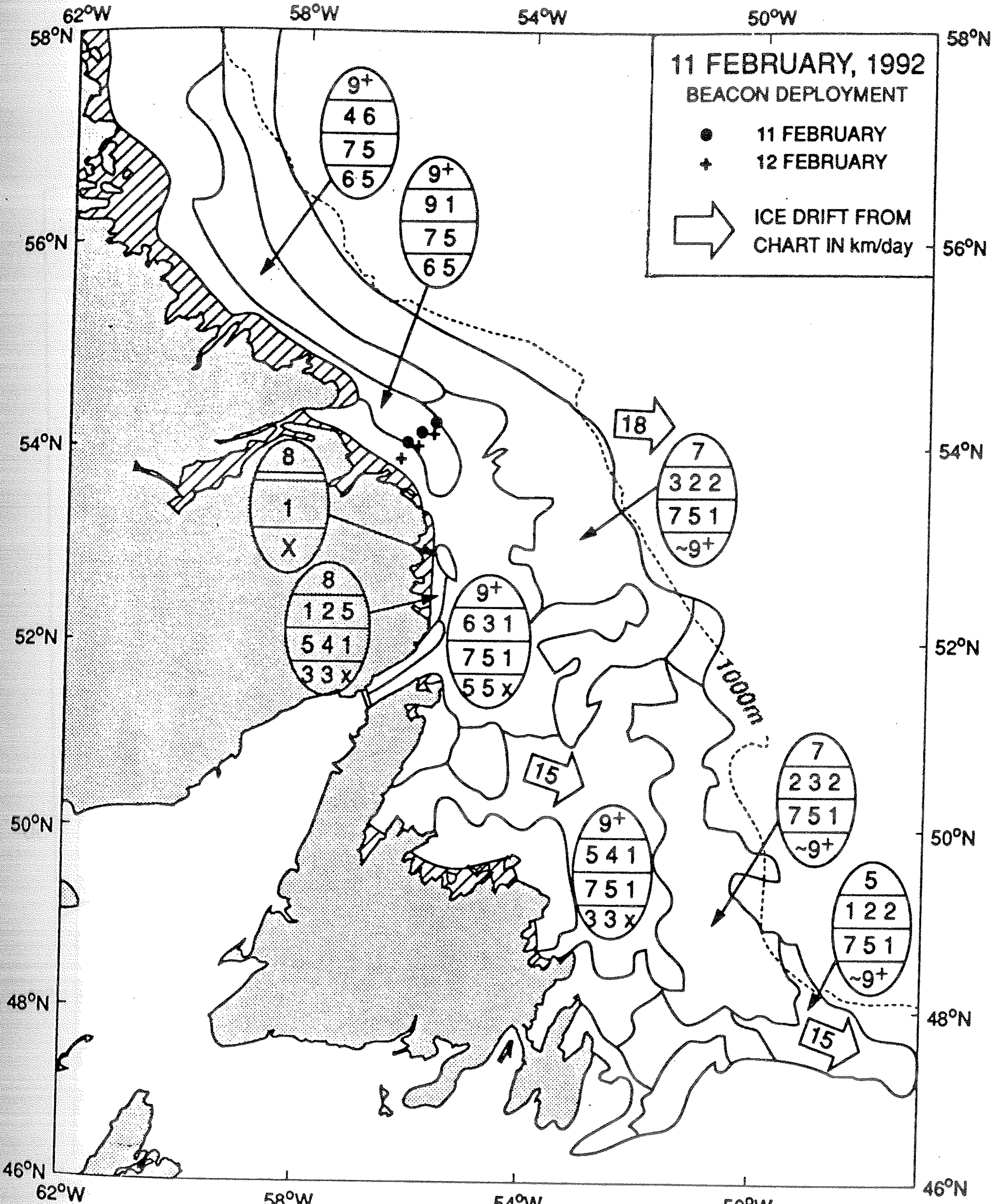


Fig. 1. Ice chart of February 11, 1992, showing the locations of the beacons deployed on February 11 and 12. Hatched area nearshore represents landfast ice.

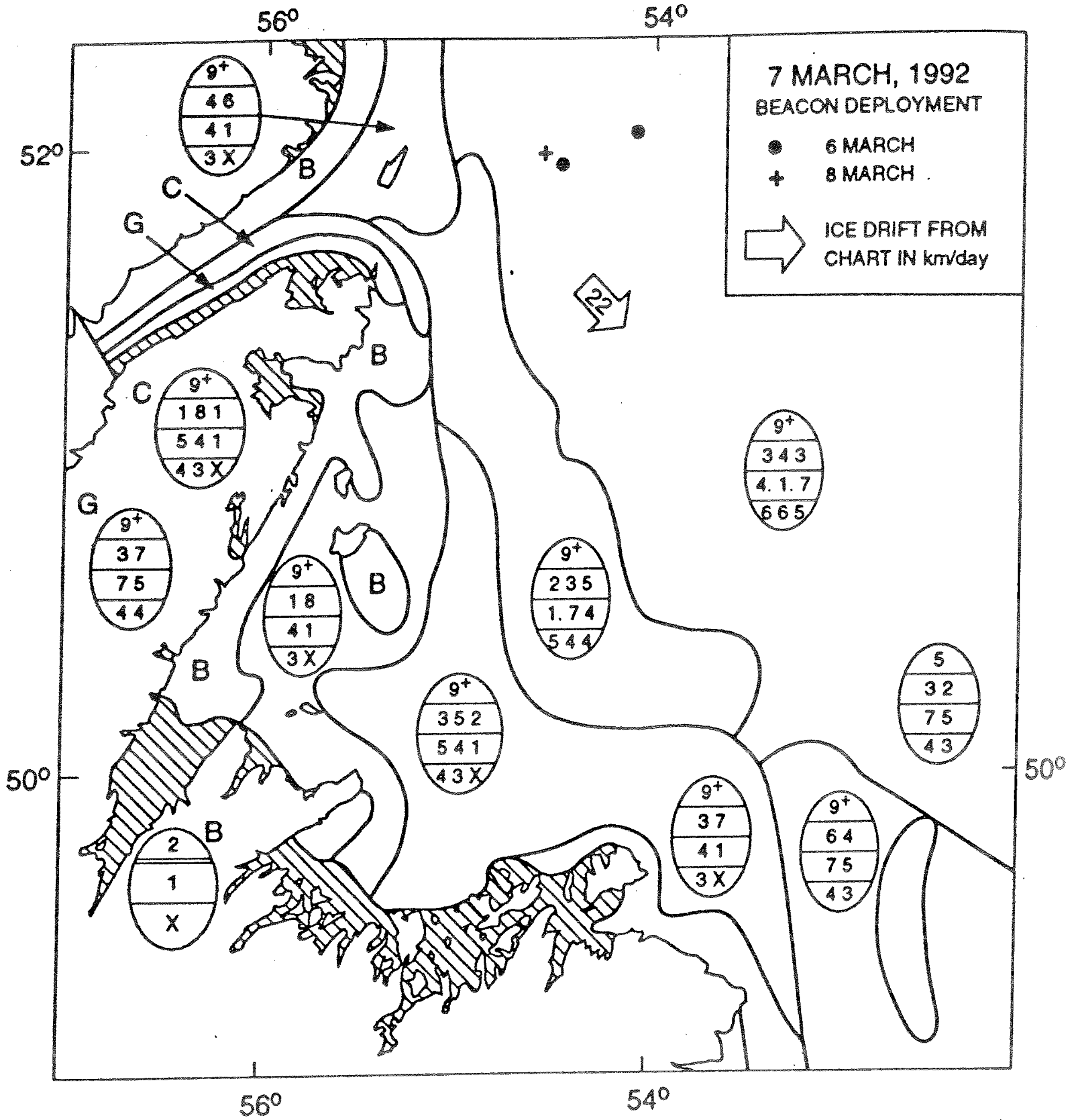


Fig. 2. Ice chart of March 7, 1992, showing the locations of the beacons deployed on March 6 and 8. Hatched areas nearshore represent landfast ice.

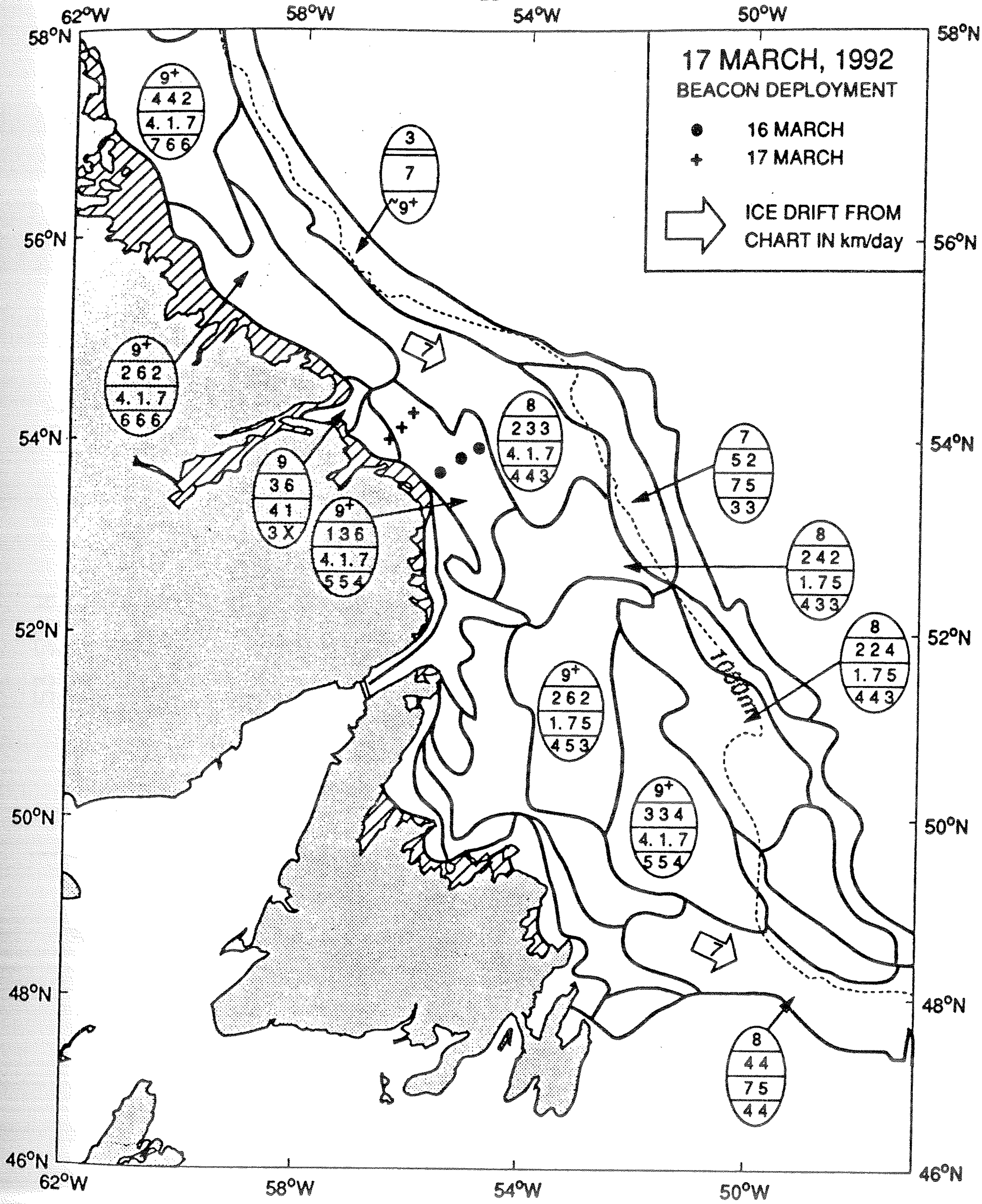


Fig. 3. Ice chart of March 17, 1992, showing the positions and 2-day displacements of the beacons deployed on March 16 and 17. Hatched areas nearshore represent landfast ice.

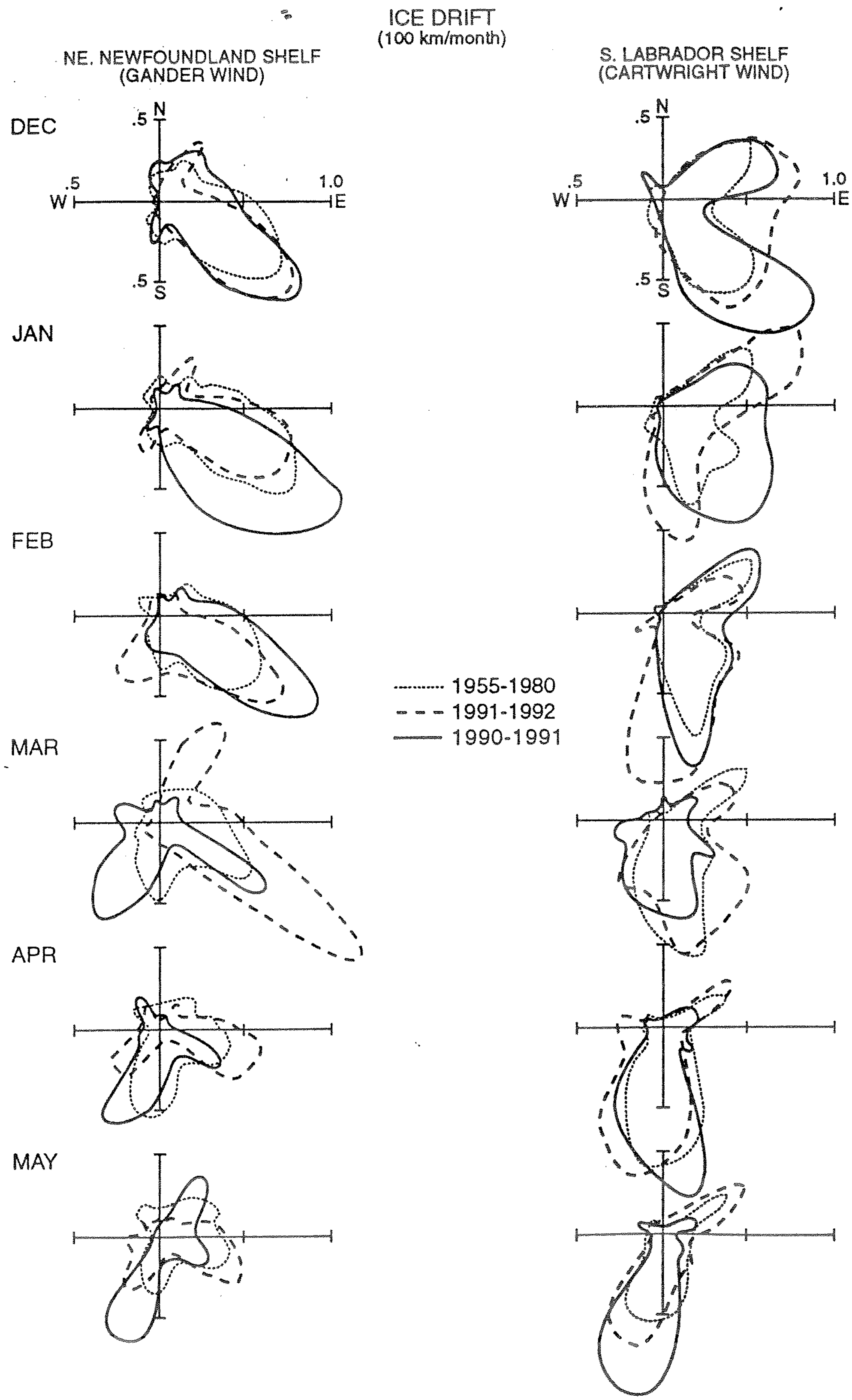


Fig. 4. Monthly contours representing the end points of 16 ice drift vectors in km/months for the 25-year mean and the 1990/91 and 1991/92 winters.

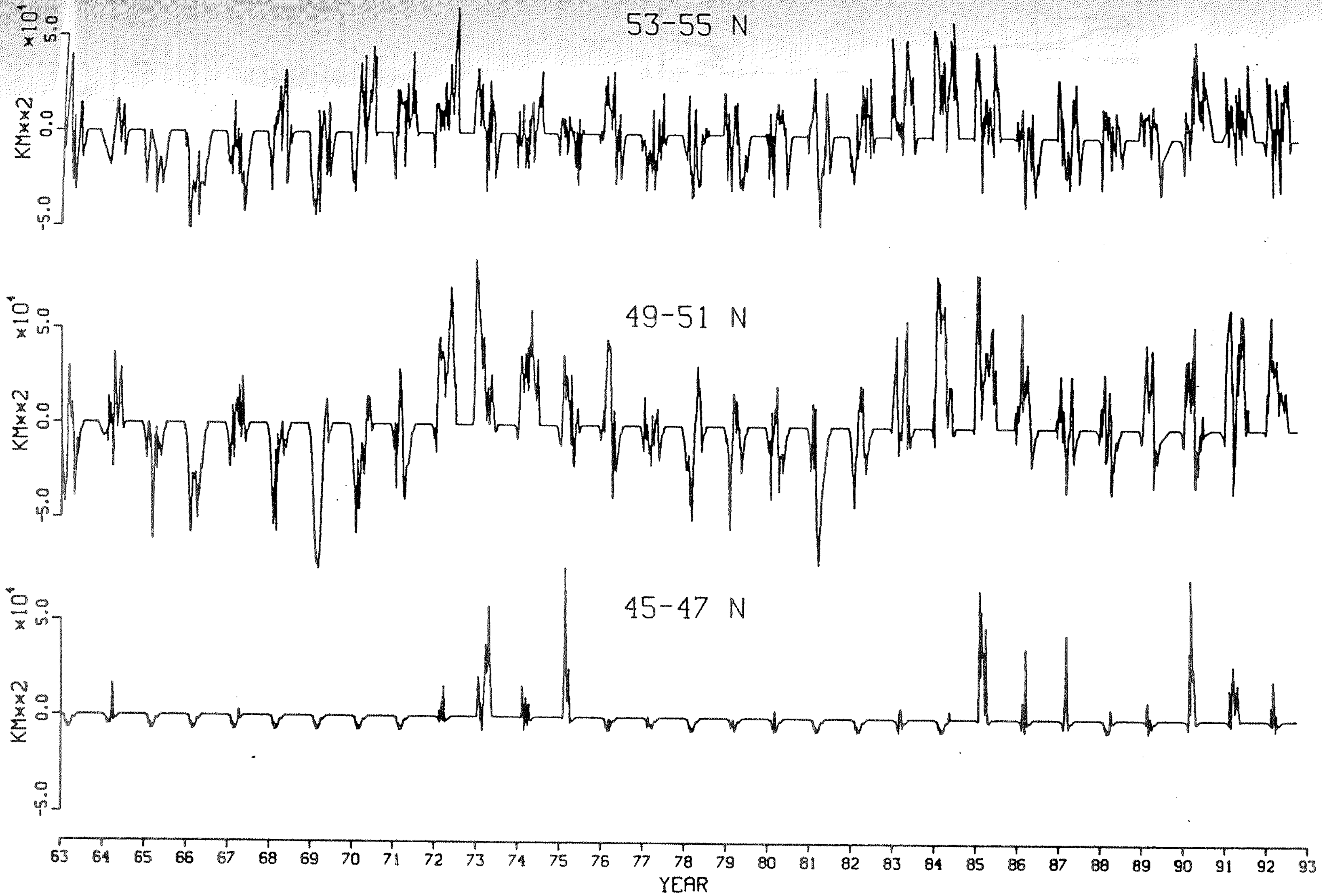


Fig. 5. Seasonal ice cover anomalies in $10^4 km^2$ (weekly values) for three areas along the Labrador/Newfoundland coast: Hamilton Bank area from 53 to 55°N, NE Newfoundland shelf from 49 to 51°N and S Grand Bank from 45 to 47°N.

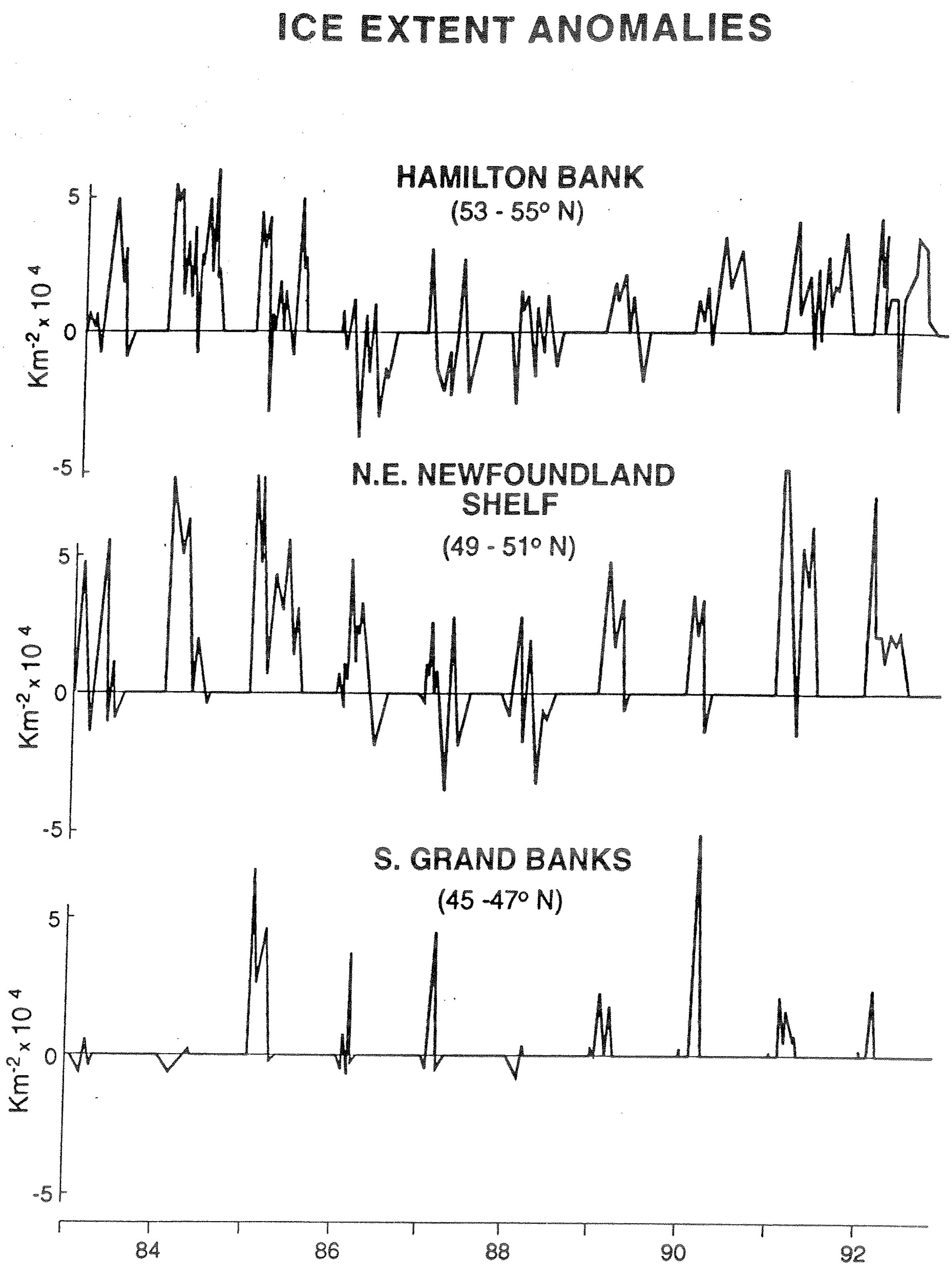


Fig. 6. Seasonal ice cover anomalies in $10^4 km^2$ (biweekly values) for three areas along the Labrador/Newfoundland coast for 1984 to 1992.

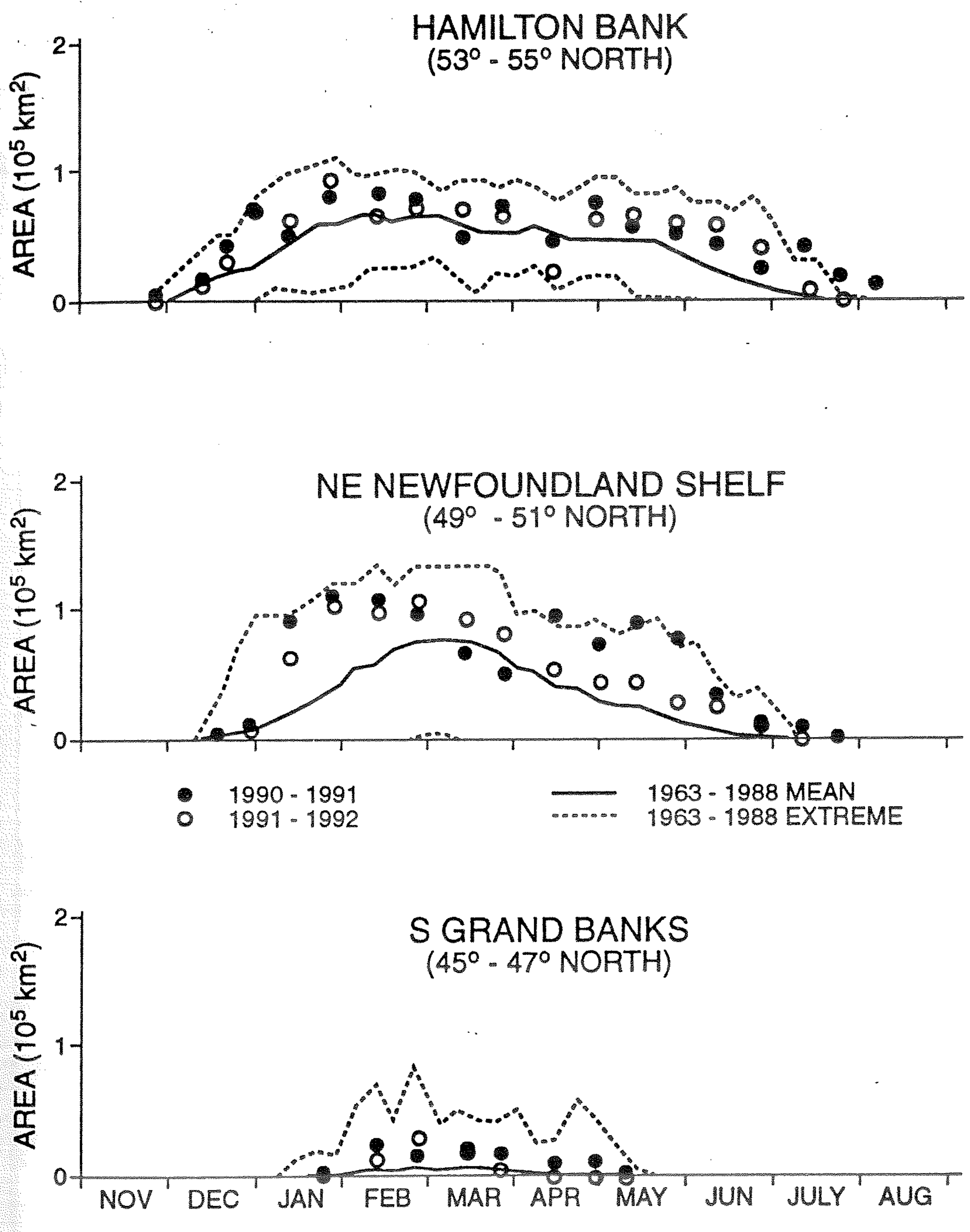


Fig. 7. Weekly mean ice extent with solid lines showing the 20-year mean, dashed lines the minimum and maximum ice extent in total 20-year records and dots the biweekly winter values of 1990/91 and 1991/1992.

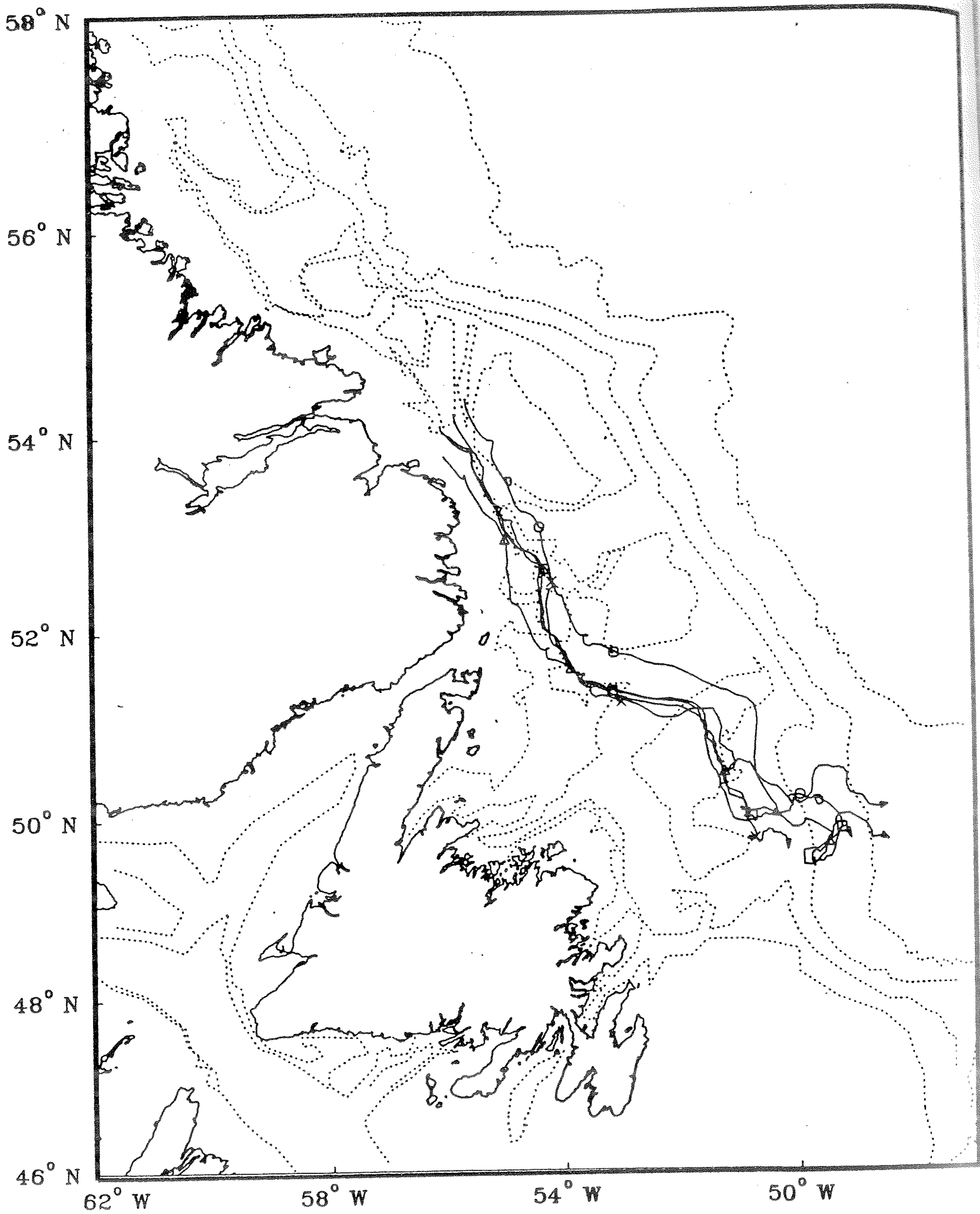


Fig. 8. Trajectories of ice beacons deployed on February 11 and 12, with positions marked every 10 days.

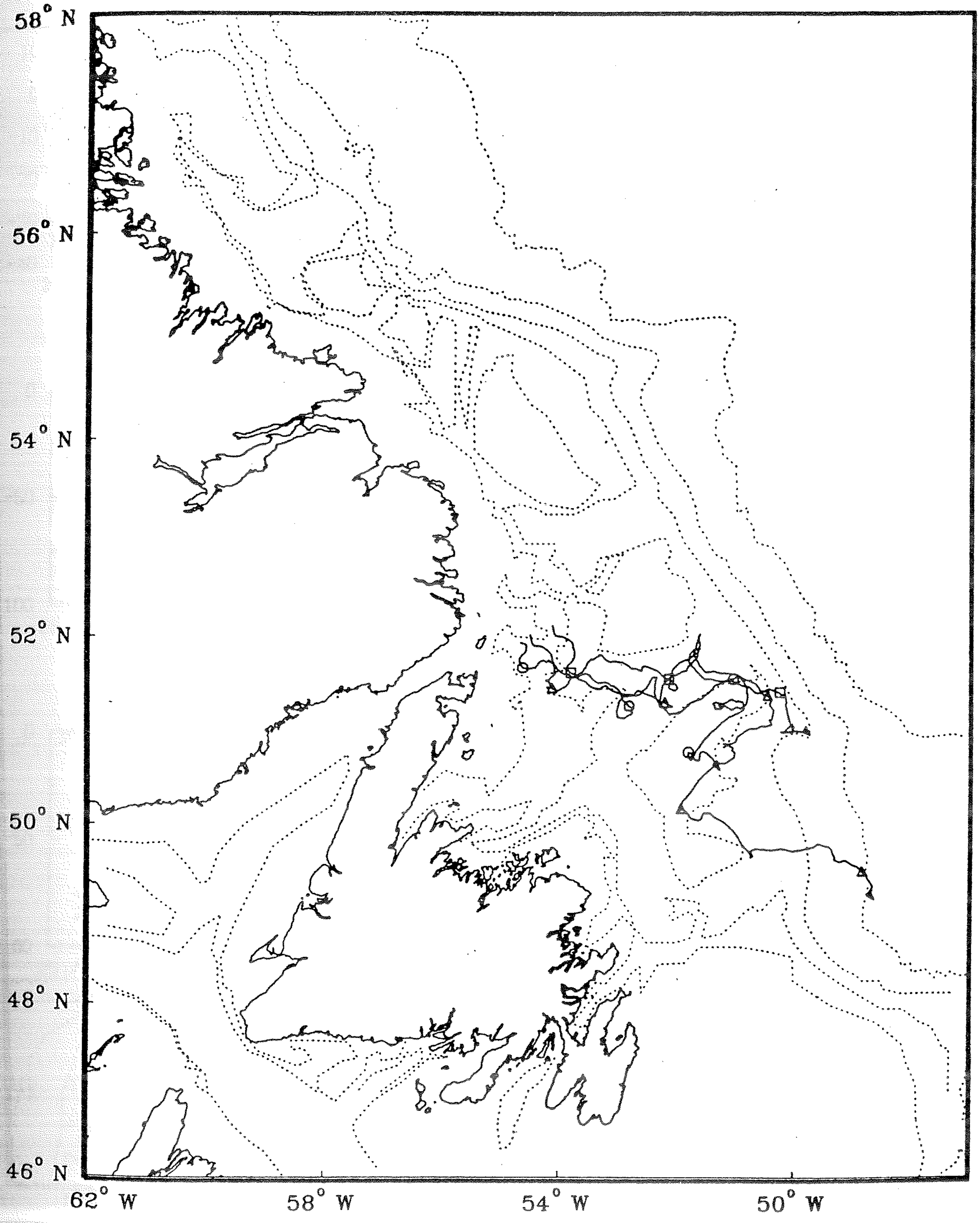


Fig. 9. Trajectories of ice beacons deployed on March 6 and 8, with positions marked every 10 days.

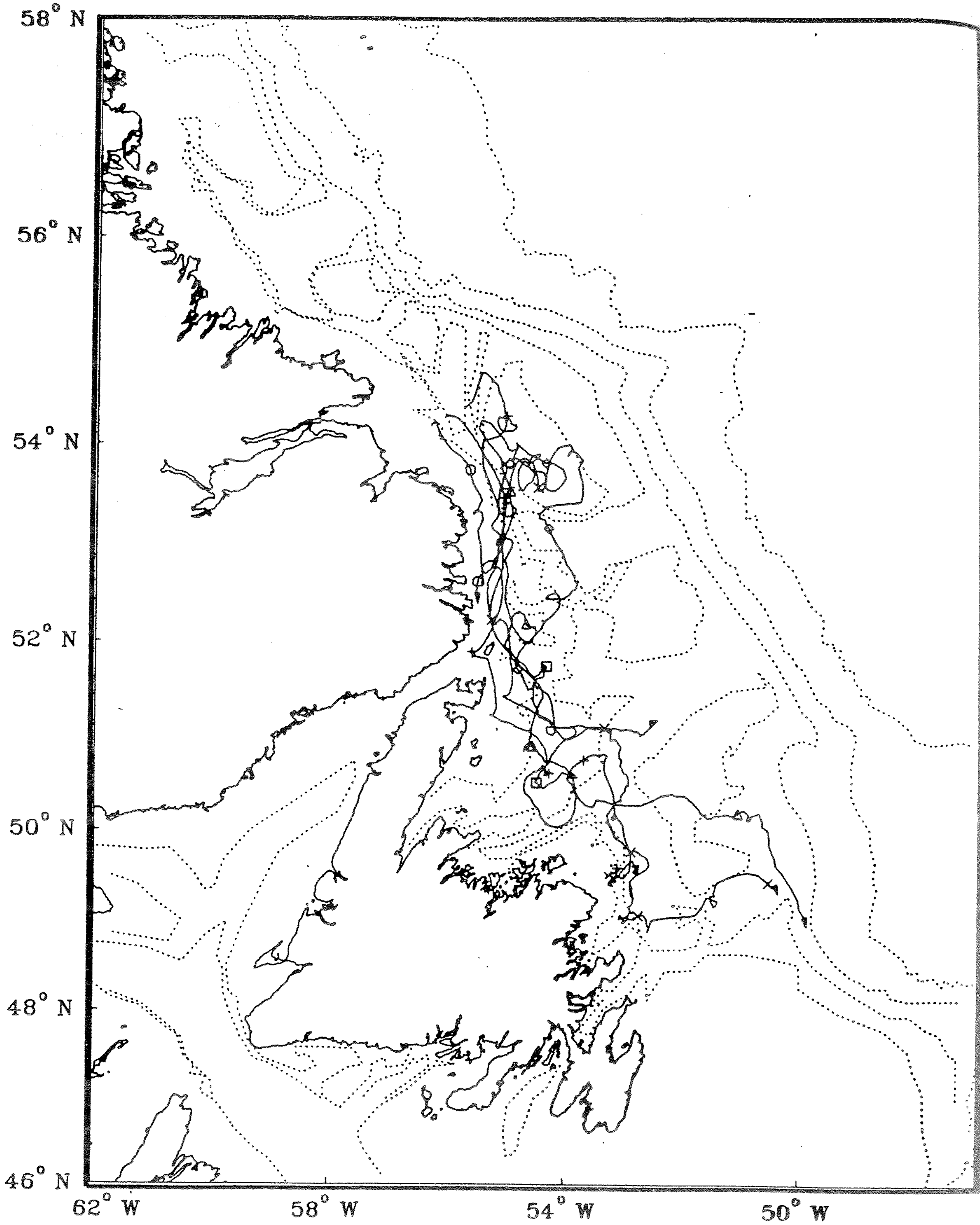


Fig. 10. Trajectories of ice beacons deployed on March 16 and 17, with positions marked every 10 days.

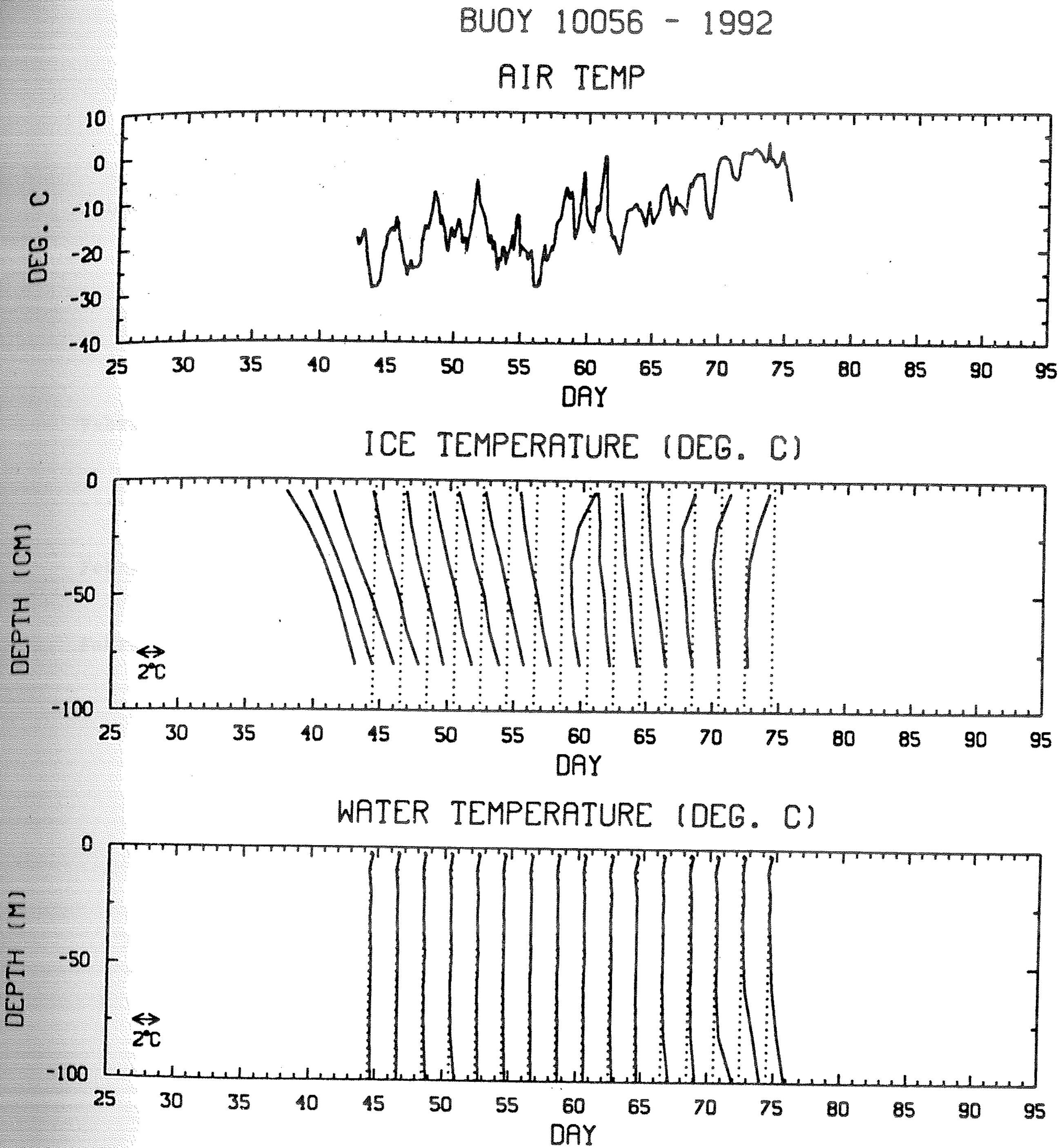


Fig. 11. Air temperature and ice/water temperature profiles from ice beacon #10056, which was deployed on drifting ice off Cartwright on February 11. Dotted vertical lines represent freezing points (-1.8°C) for the profiles, and 1 day=1°C in temperature.

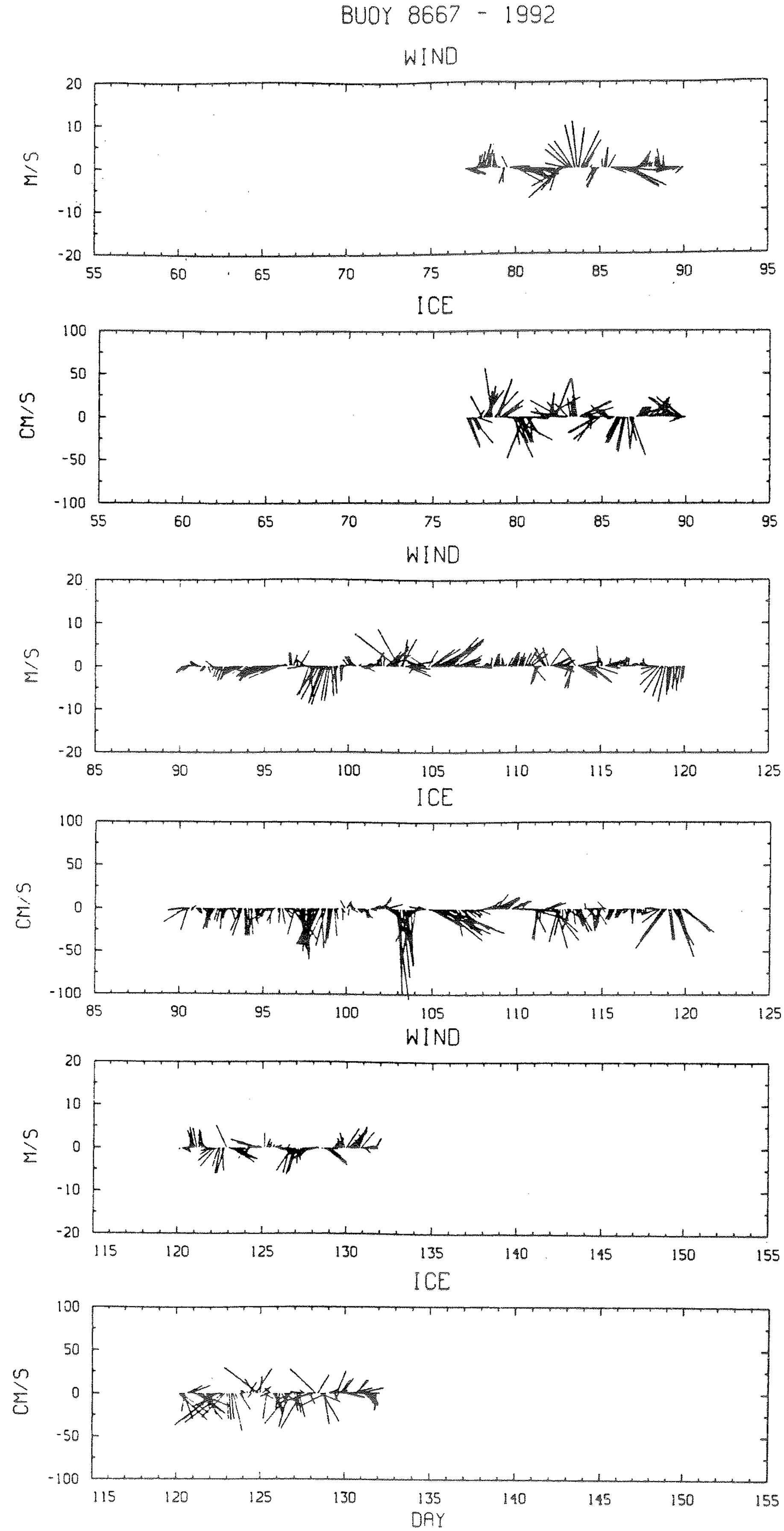


Fig. 12. Stick plots of wind and ice velocity (3-hourly) from beacon #8667.

APPENDIX A: FIELD PROGRAM SCHEDULE

January 31 - G. Fowler and D. Davis deployed four beacons on land-fast ice in Sandwich Bay near Cartwright, Labrador.

Sta. 9201:- Atmospheric beacon, ARGOS #4757
- Thrust Anemometer, ARGOS #3326
- Small IMP, ARGOS #1056
- Temp. Chain (50m), ARGOS #10055

February 3-6 - Atmospheric beacon #4757 not reporting.

February 10 - Beacons and CTD tested in Universal Hanger, Goose Bay. Anemometer beacon #8664 not working.

February 11 - February ice beacon deployment trip off southern Labrador coast (Black Tickle). Two Universal helicopters, pilots: Ron Moores and Paul Garrett, and Simon Prinsenberg and Paul d'Entremont from BIO. Light winds from NW, -24°C and a large swell running.

Sta. 9202:
- About 60 miles offshore; location beacon #3320
- 200^{+} cm of ice and 19cm of snow
- Rafted floe, 75mx75m
- Three ice samples; no CTD, too cold.

Sta. 9203:
- About 40 miles offshore; Temp. Chain #10056
- 1.6-2.0m of ice; and 21cm of snow
- Rafted floe, 75x75m
- Salinity/Temperature profiles from floe edge
- Top of temp. chain in air due to large freeboard

Sta. 9204:
- About 20 miles offshore; small IMP #1057
- 2.2^{+}m of ice and 19cm of snow
- Rafted floe, 40mx50m with 1m freeboard at places
- Salinity/Temperature profiles from floe edge
- Four ice chip samples
- Top of Temp. staff in air due to 1/2m freeboard

Sta. 9201:
- Sandwich Bay near Cartwright
- All four beacons received by Telonics
- 64cm of ice, 10cm of hard and 8cm of soft snow; changed legs on Temp. chain
- Three ice chip samples
- Thrust anemometer operated from 1530 EST Feb.11 to 0950 EST Feb.12

February 12 - Transect off Cartwright; winds 15-25knots from NW and -22°C

Sta. 9205:
- Low visibility restricted offshore extent to 40 miles; Anemometer beacon #8663
- 1.6m of ice and 9cm of snow
- Rafted floe, 40mX60m
- Salinity/Temperature profiles
- Four ice chip samples
- Strong ice drift 1kt from GPS positions

Sta. 9206:
- About 30 miles offshore; Temp. chain #10054
- 2.8m of ice and 24cm of snow
- Rafted floe, 40mx50m; blocks 70cm thick
- Four ice chip samples
- Too windy and cold for CTD

Sta. 9207:
- About 20 miles offshore; location beacon #3321
- 2.0^{+}m of ice and 4cm of snow
- Rafted floe, 50mx75m
- Salinity/Temp. profiles through 30cm thick ice
- Three ice chip samples

February 13 - Shipped broken CTD and beaon #8664 back to BIO
Total 18.2 hours flown on February trip

March 14 - Beacons and CTD equipment moved to Canadian Helicopter hanger. Six (plus spare) beacons tested at Goose Bay for March trip.

March 15 - Poor weather. Worked on beacons and packed helicopters.

March 16 - March ice beacon deployment trip off southern Labrador coast (Black Tickle). Two Canadian helicopters; pilots Henry Blake and Bob Bartlet and S. Prinsenberg and P. d'Entremont from BIO. Winds at 20 kt from the NW and -12°C.

Sta. 9208:
- About 60 miles offshore; location beacon #8647
- 2.1^{+}m of ice and refrozen snow
- Rafted floe, 40mx60m; very slippery
- Salinity/Temp. profiles
- Four ice chip samples

Sta. 9209:
- About 40 miles offshore; Temp. chain #10053
- 2.4^{+}m of ice and 4cm of hard frozen snow
- Rafted floe, 50mx50m
- Salinity/Temp. profiles
- Five ice chip samples

Sta. 9210: - About 20 miles offshore; Atmospheric beacon 8667
- 130-165cm of ice and 10 cm of refrozen snow
- Rafted floe, 50mx50m
- Salinity/Temp. profiles
- Four ice chip samples

Sta. 9201: - Sandwich Bay to recover malfunctioning beacons
- 78cm of ice and -7 cm of freeboard
- 33cm of hard snow and 7cm of loose snow
- Salinity/Temp. profiles
- Three ice chip samples

March 17 - Clear, no wind and -15°C.

Sta. 9211: - 40 miles offshore; location beacon #8649
1.3-2.1m of ice with 19cm of freeboard
- Rafted floe, 50mx50m
- 5cm of snow covered with 3/4cm of ice
- Salinity/Temp. profiles
- Four ice chip samples

Sta. 9212: - About 30 miles offshore; small IMP #1052
- 142cm of ice, 3cm of snow and 3/4cm of ice
- Rafted floe, 50mx30m
- Salinity/Temp. profiles
- Four ice chip samples

Sta. 9213: - About 30 miles offshore; CMIB beacon #4763
- Soft 54cm of ice 2cm of snow and 3/4cm of ice on top of snow
- Large floe, 200mx200m
- Salinity/Temp. profiles
- Four ice chip samples

Sta. 9214: - Lake Melville off Long Point
- 162cm of hard ice and 10cm of snow
- Salinity/Temp. profiles to 25m
- Four ice chip samples

March 18 - Shipped CTD and equipment back to BIO
Total 15.3 hours flown on March trip

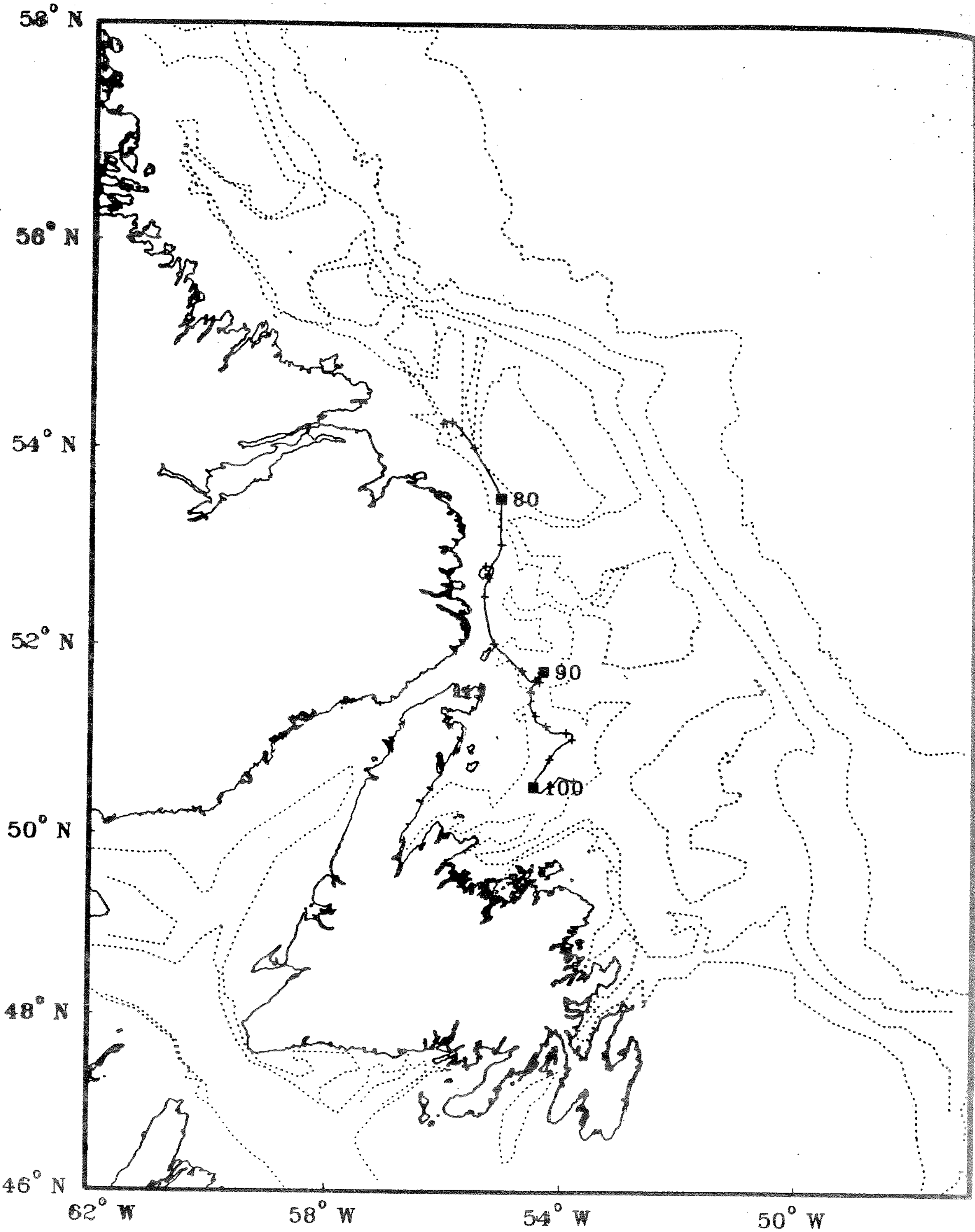
APPENDIX B: ICE BEACON TRAJECTORIES

Trajectories of the ice beacons deployed on drifting pack ice in 1992, with positions at 1800 hours GMT marked every day, and labelled every 10 days. The end time below reflect either when the beacon failed, or when the ice beneath the beacon melted.

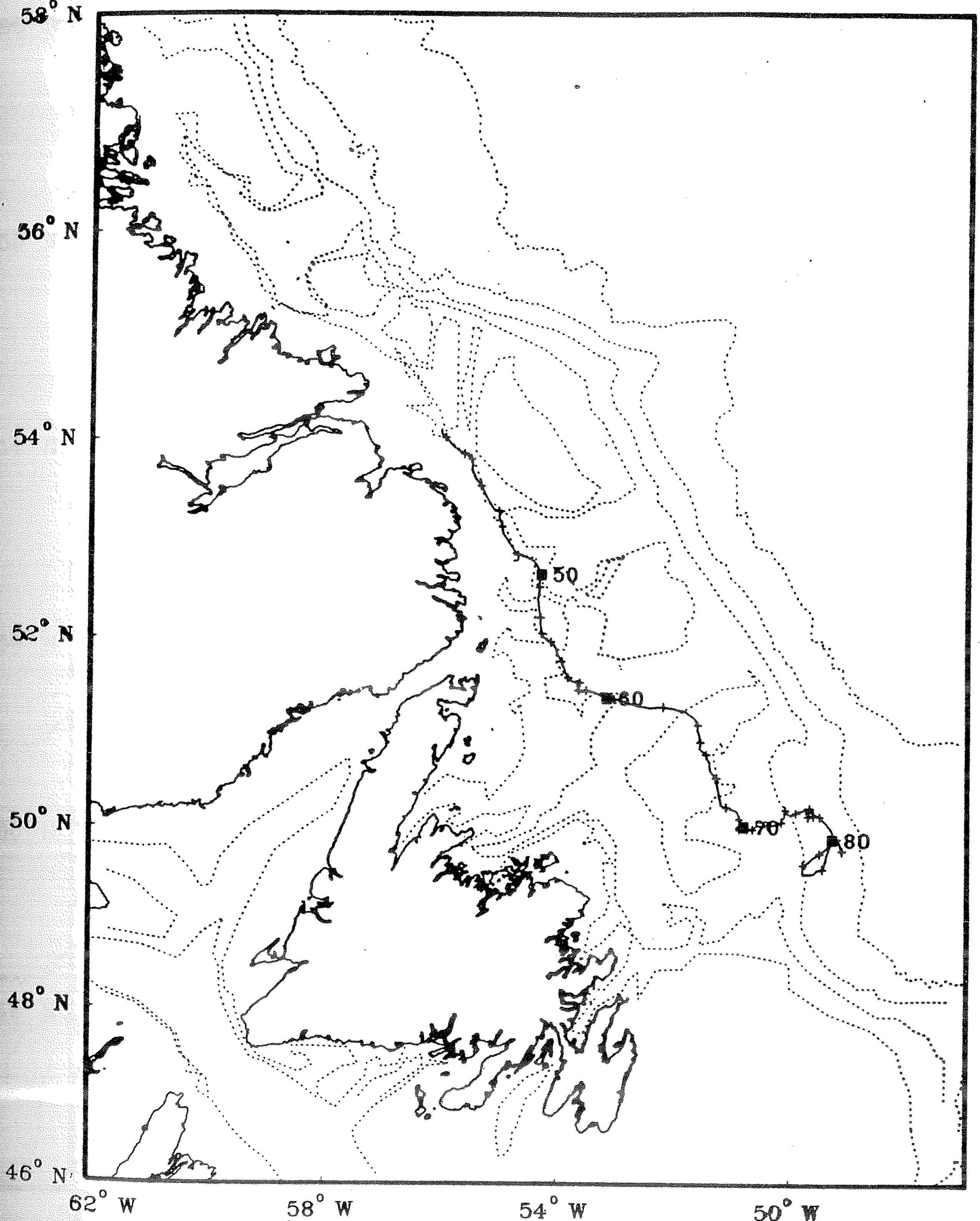
Beacon ID #	Start Time*	End Time*	Type
1052	77	102	Ice staff (SIMP)
1057	42	85	Ice staff (SIMP)
3320	42	77	Location
3321	43	88	Location
4758	66	96	Location (CMIB)
4759	68	103	Location (CMIB)
4760	66	111	Location (CMIB)
4763	77	92	Location (CMIB)
8647	76	115	Location
8649	77	137	Location
8667	76	133	Anemometer
10053	76	109	Temp. Chain
10054	43	73	Temp. Chain
10056	42	75	Temp. Chain

* times in 1992 calendar days.

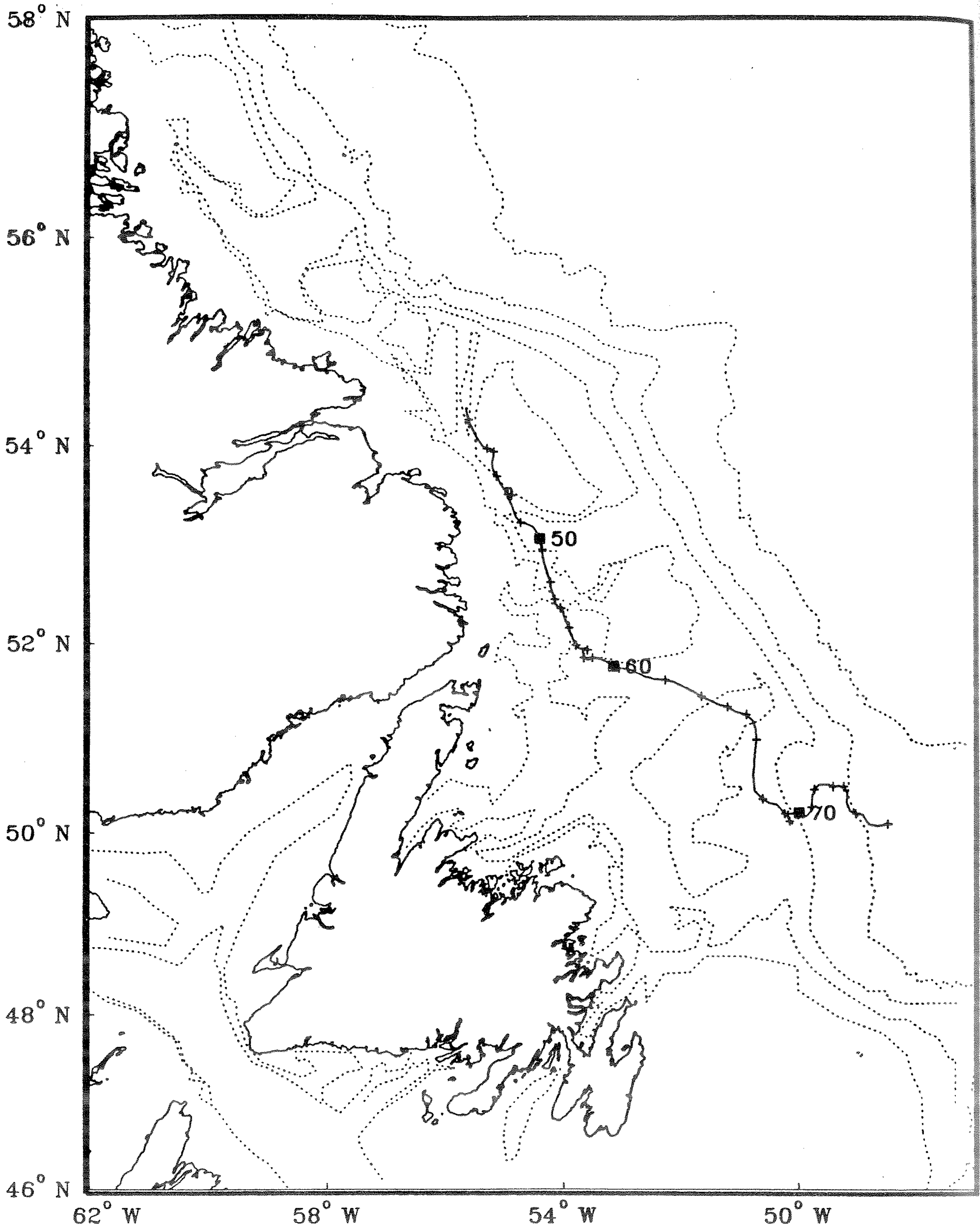
BUOY 1052 - 1992



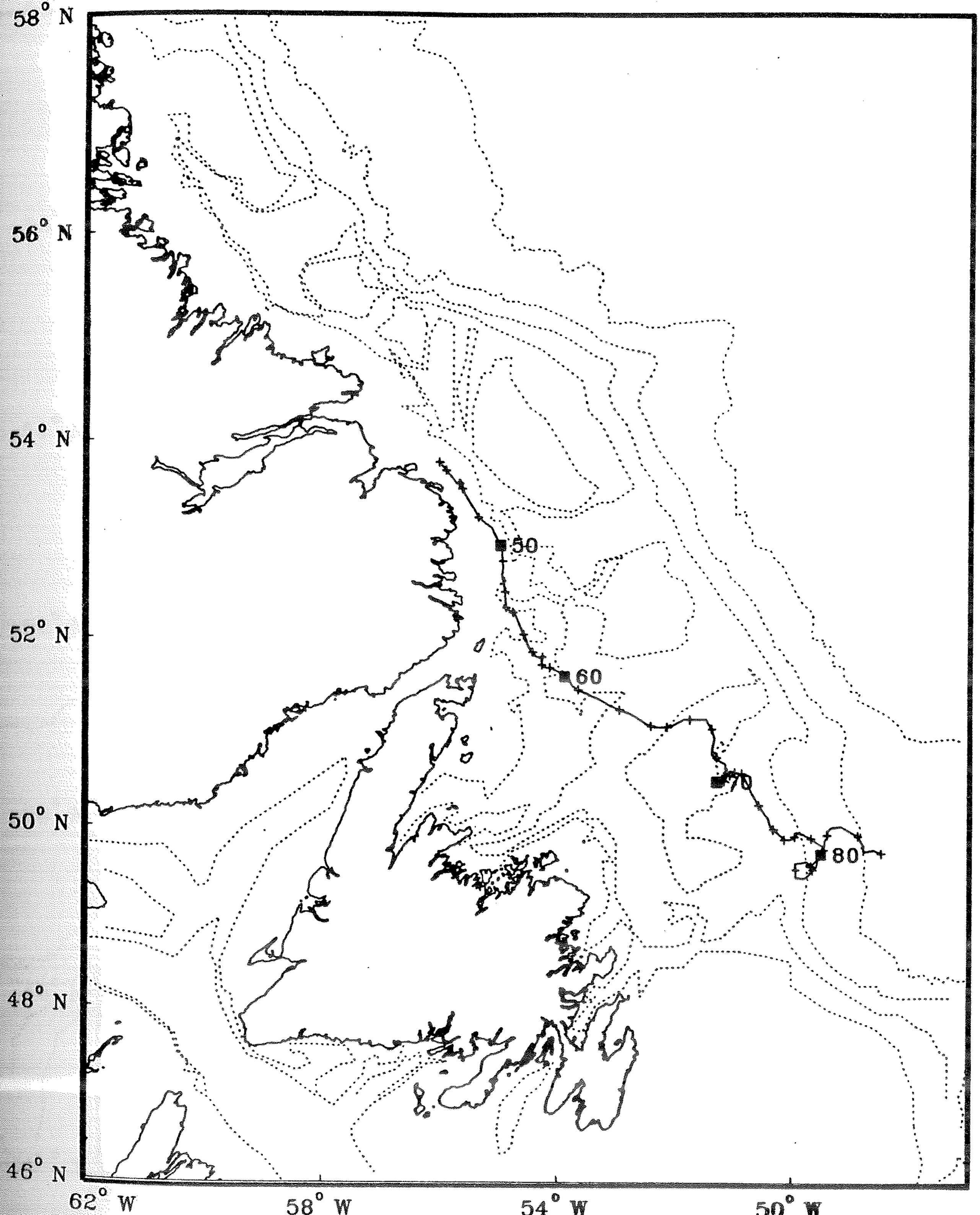
BUOY 1057 – 1992



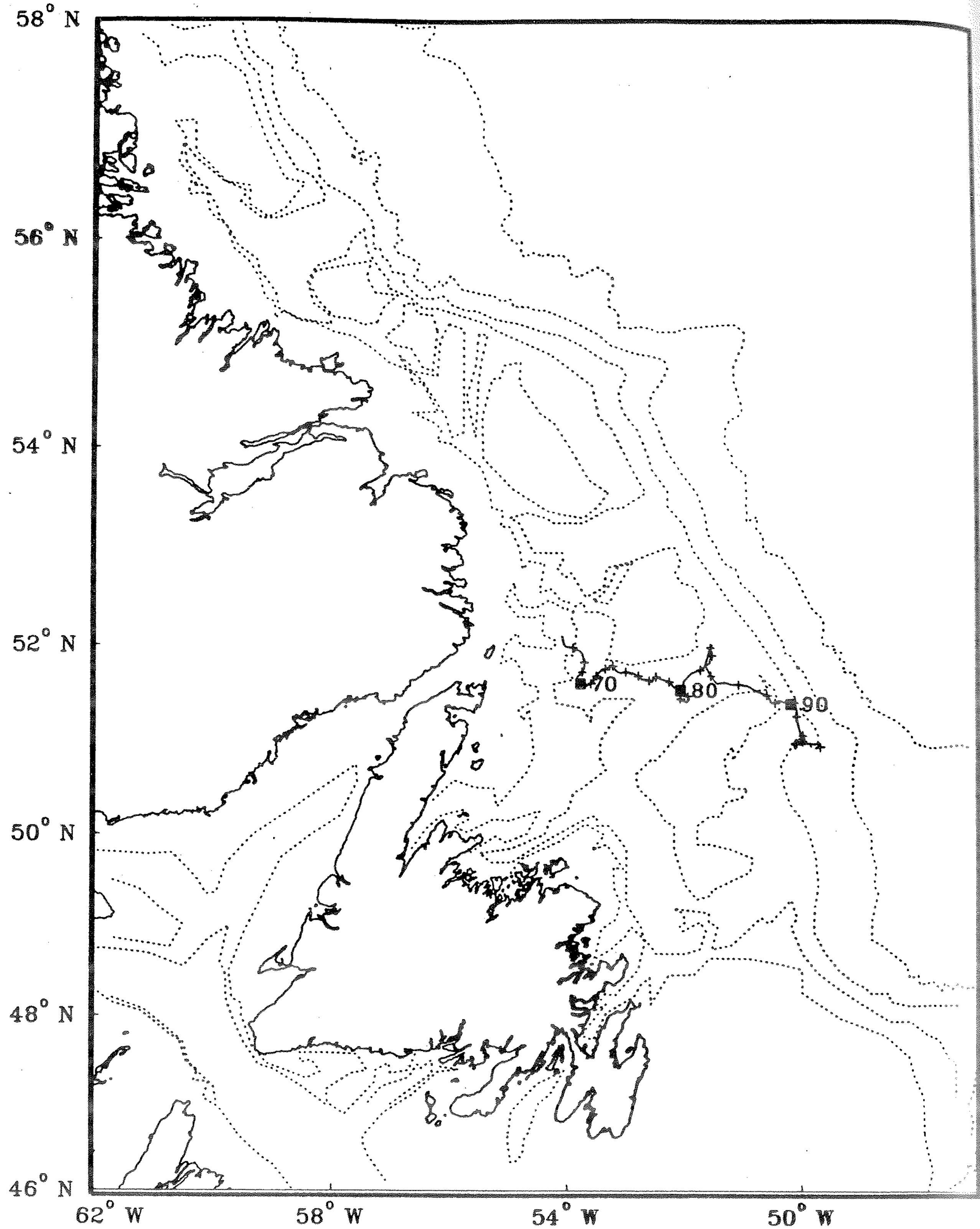
BUOY 3320 – 1992



BUOY 3321 - 1992

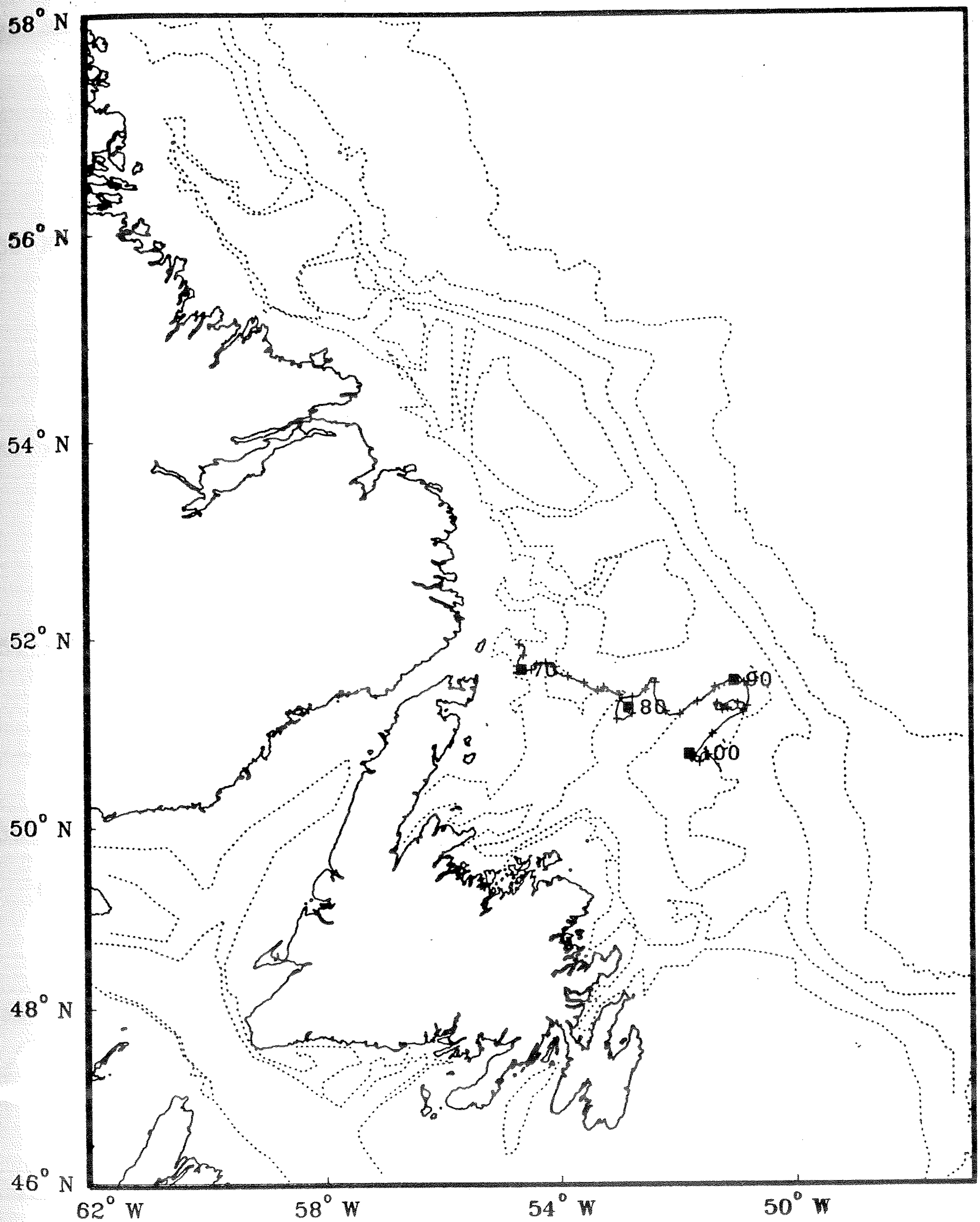


BUOY 4758 – 1992

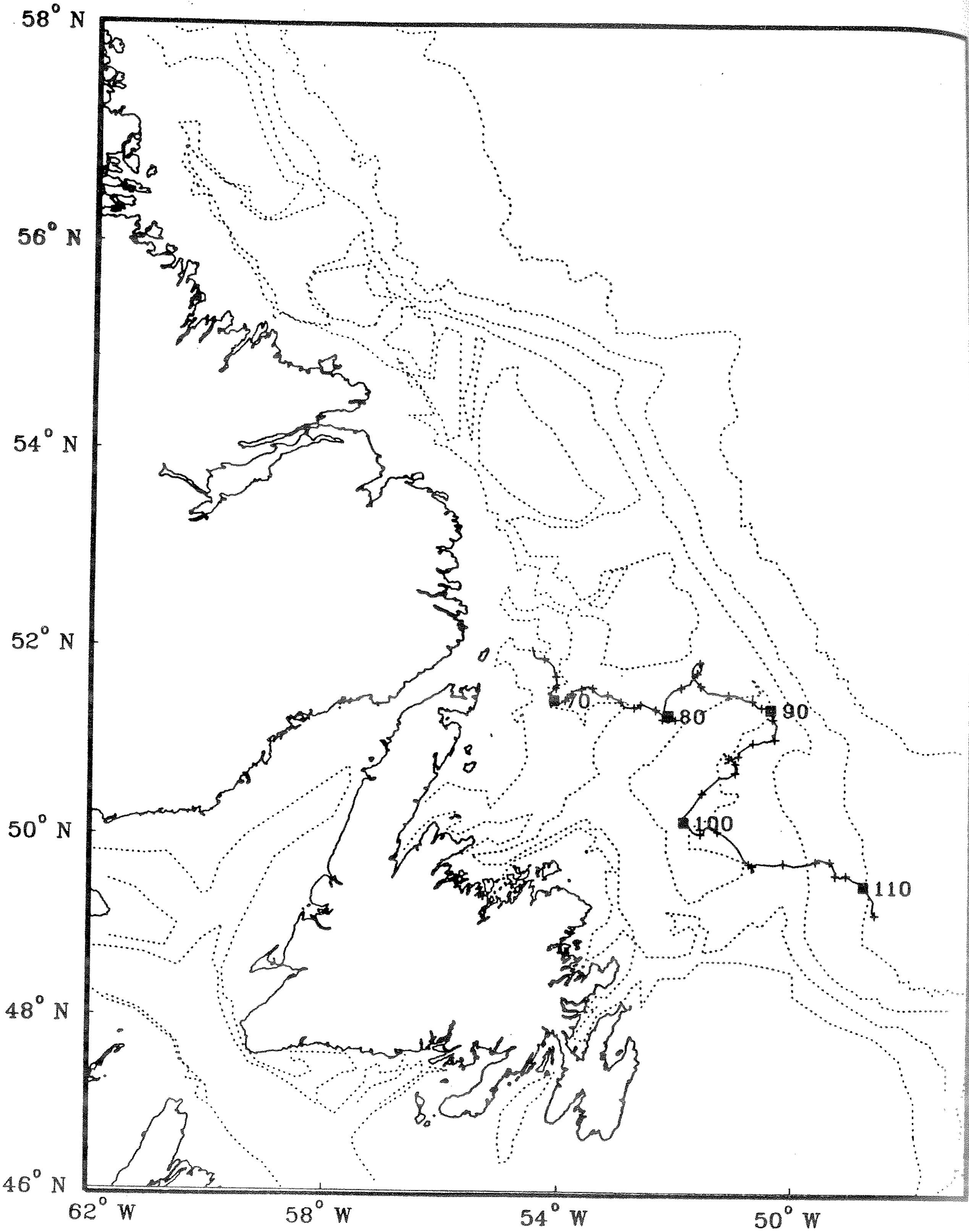


1 13.56.21 TUES 10 JAN 1989 JOB-AJZG , BEDFORD INSTITUTE DISSPLA 9.0

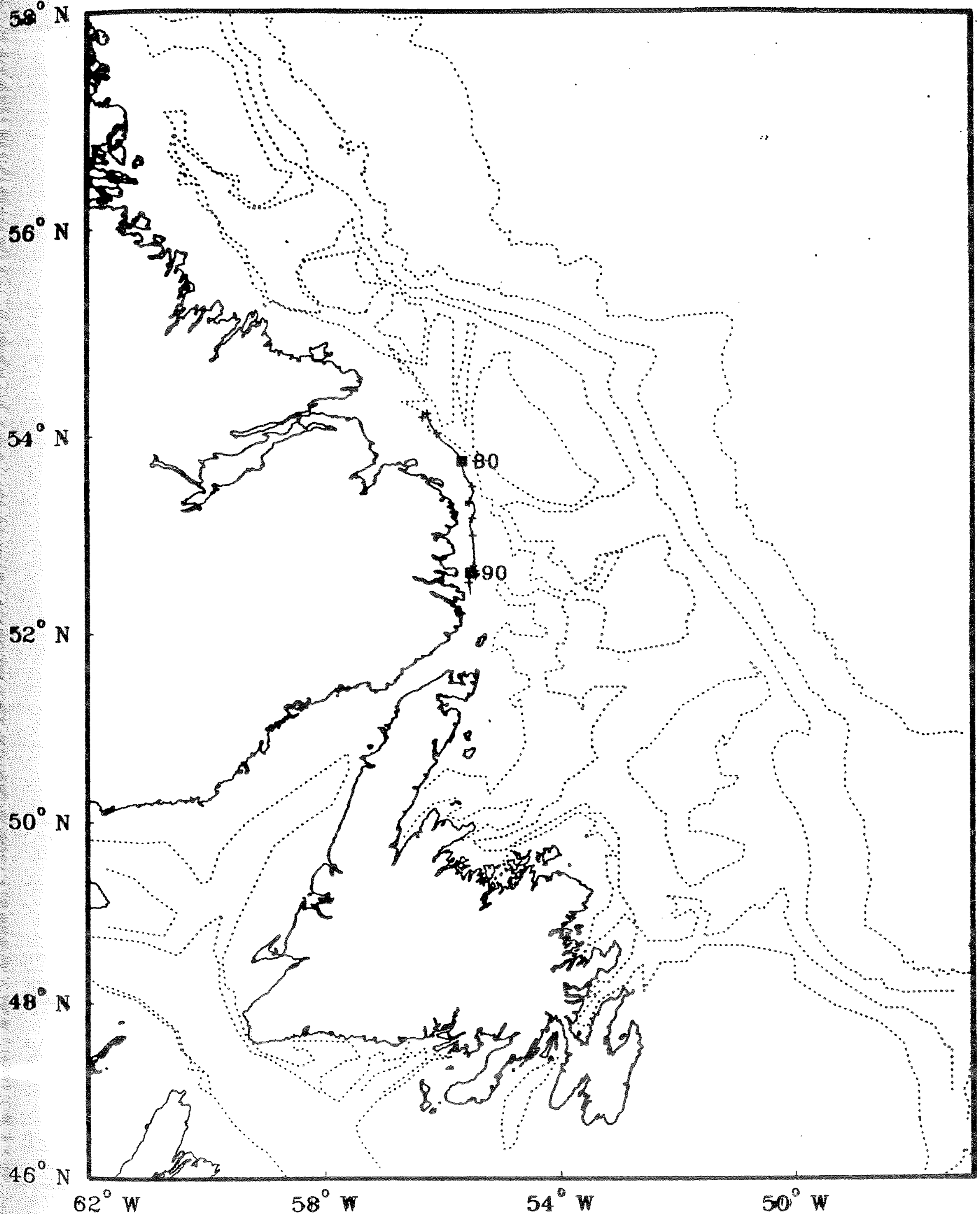
BUOY 4759 – 1992



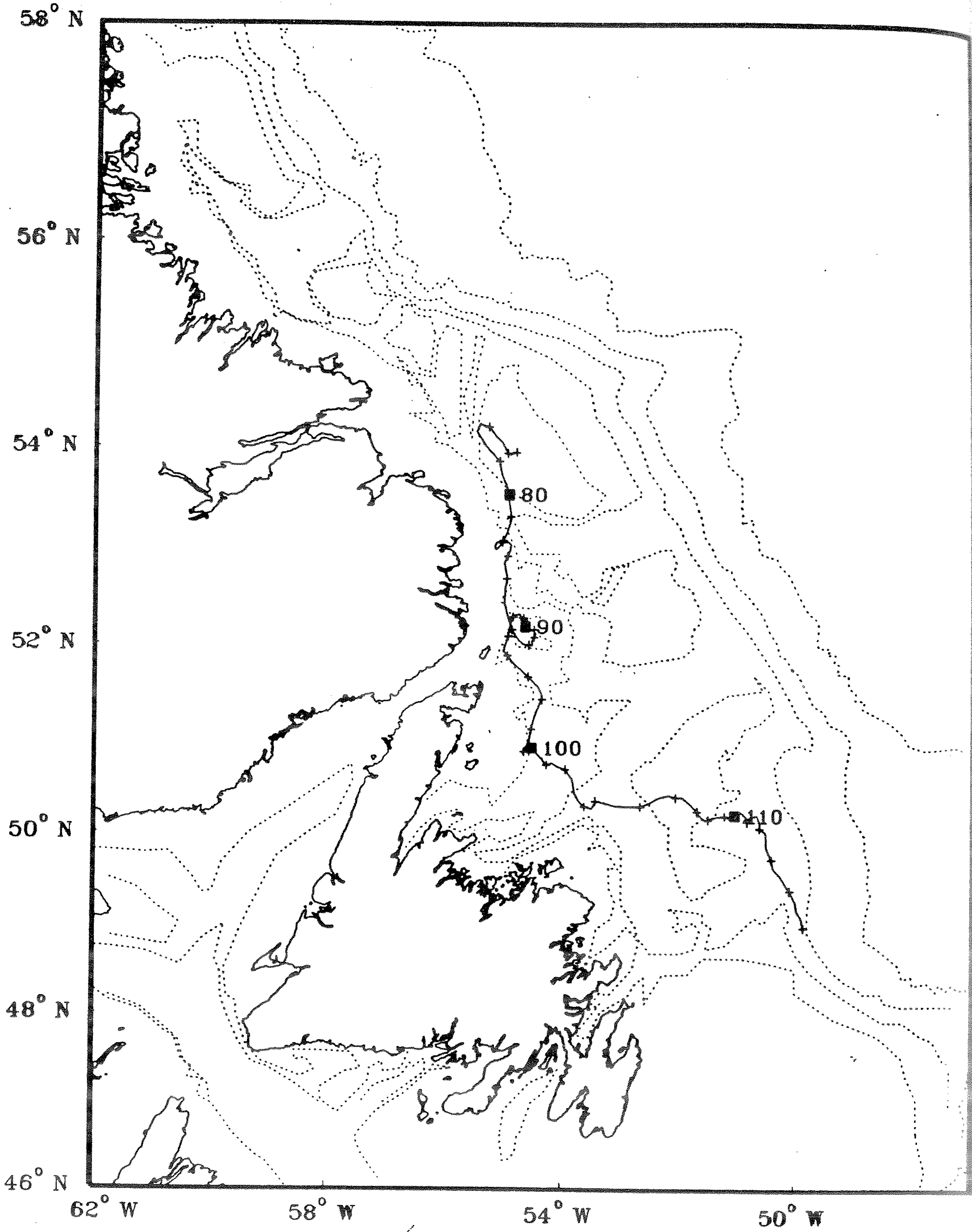
BUOY 4760 – 1992



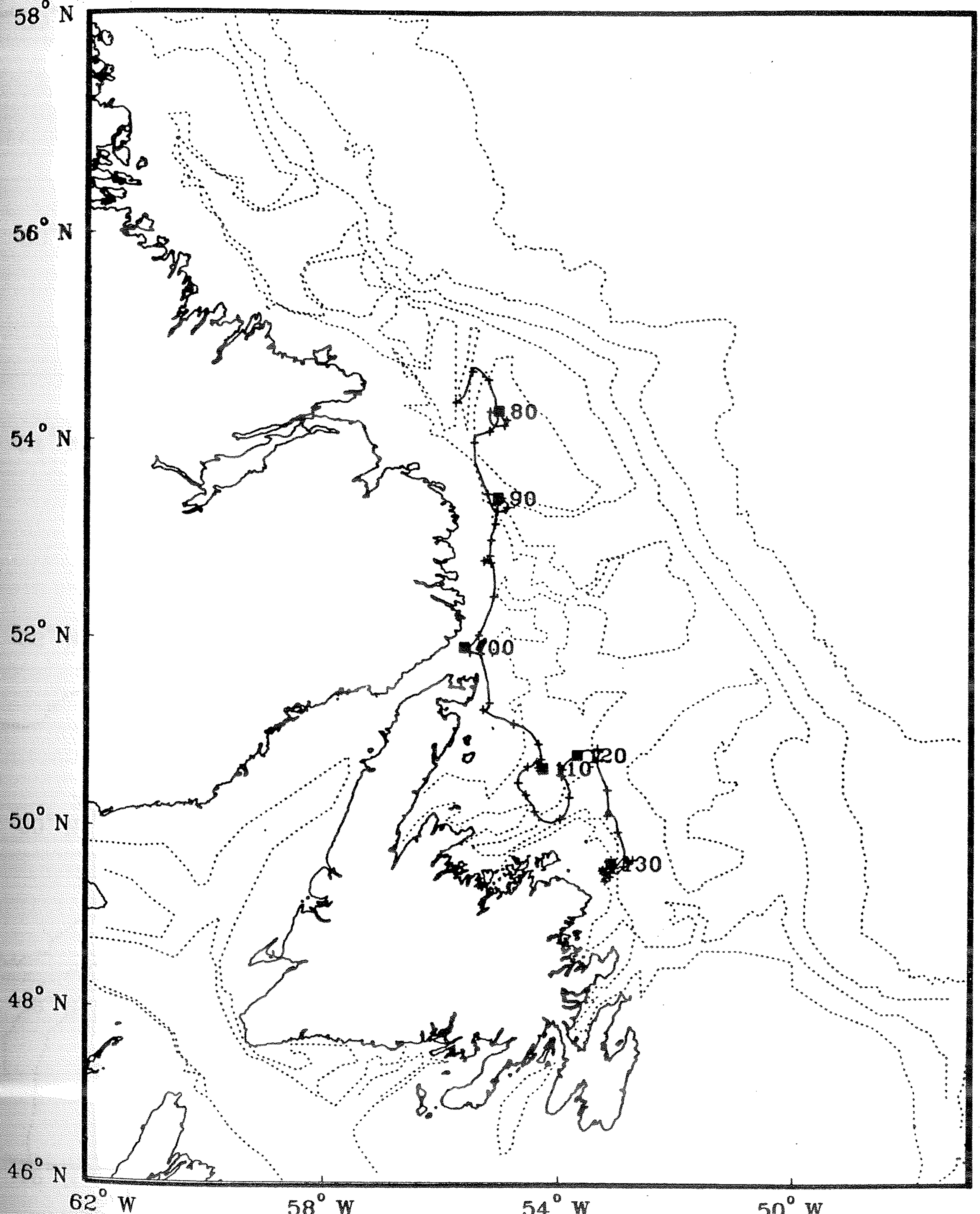
BUOY 4763 – 1992



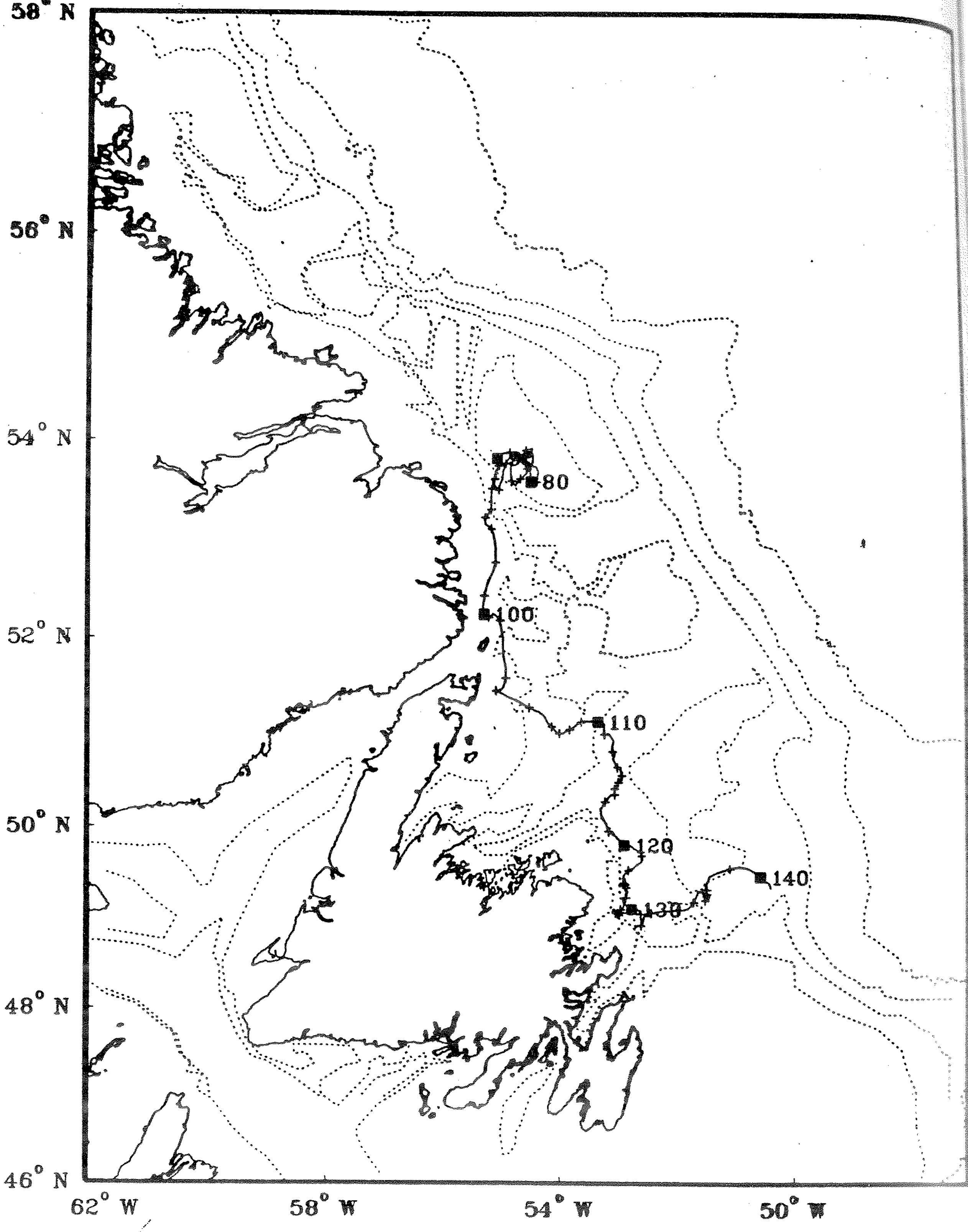
BUOY 8647 - 1992



BUOY 8649 – 1992



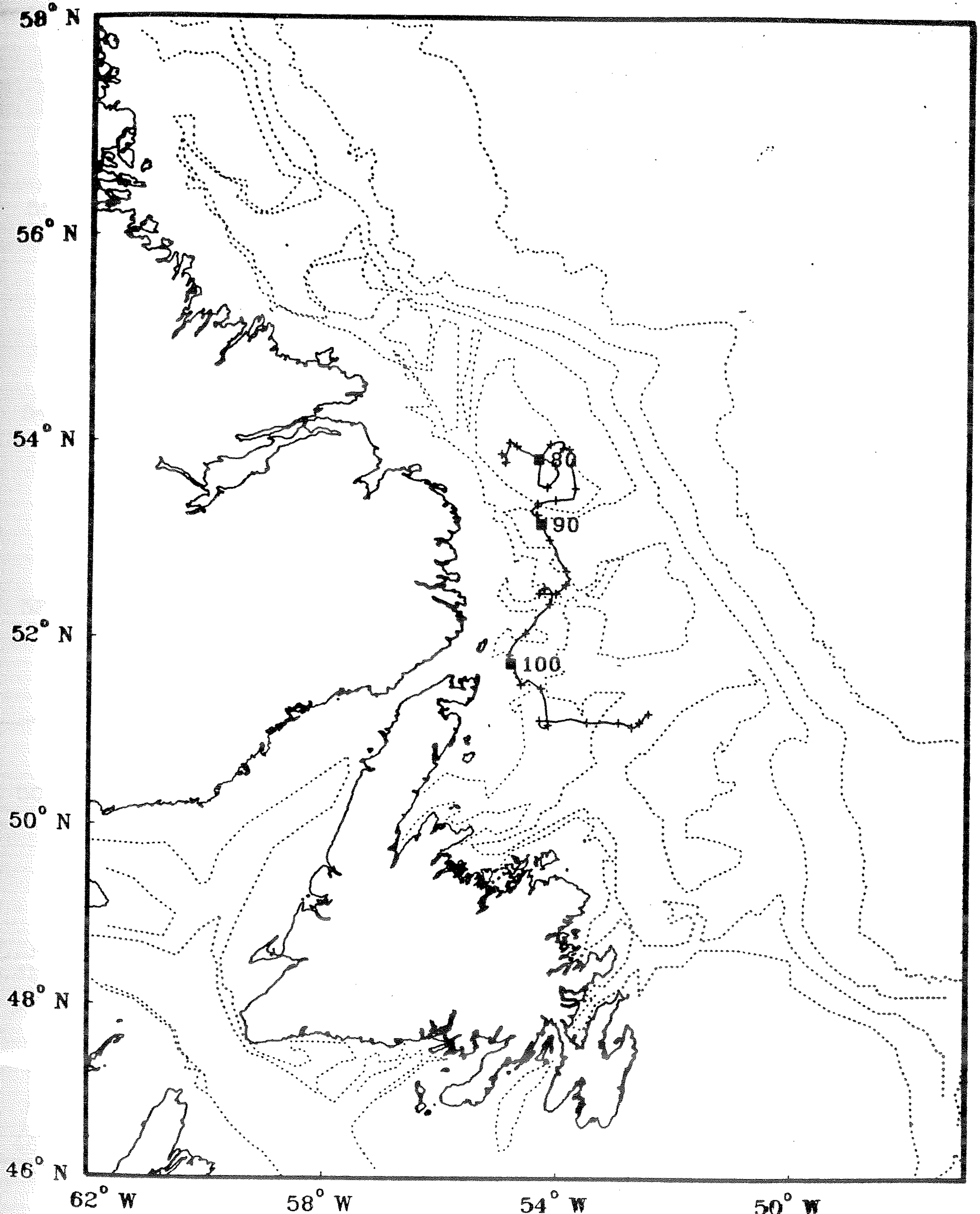
BUOY 8667 – 1992



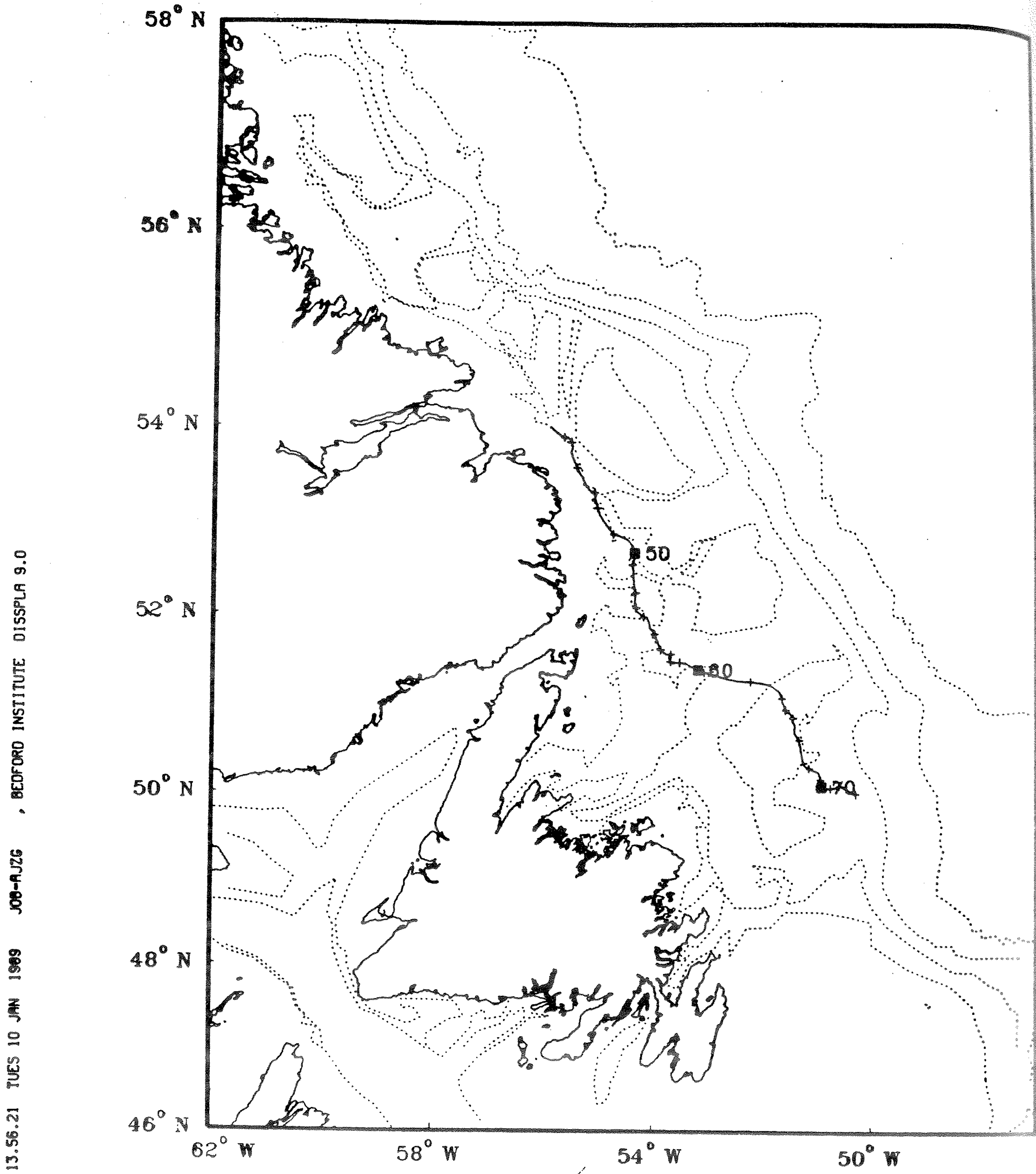
13.56.21 TUES 10 JAN 1989 JOB-AJZG , BEDFORD INSTITUTE DISSPLA 9.0

1

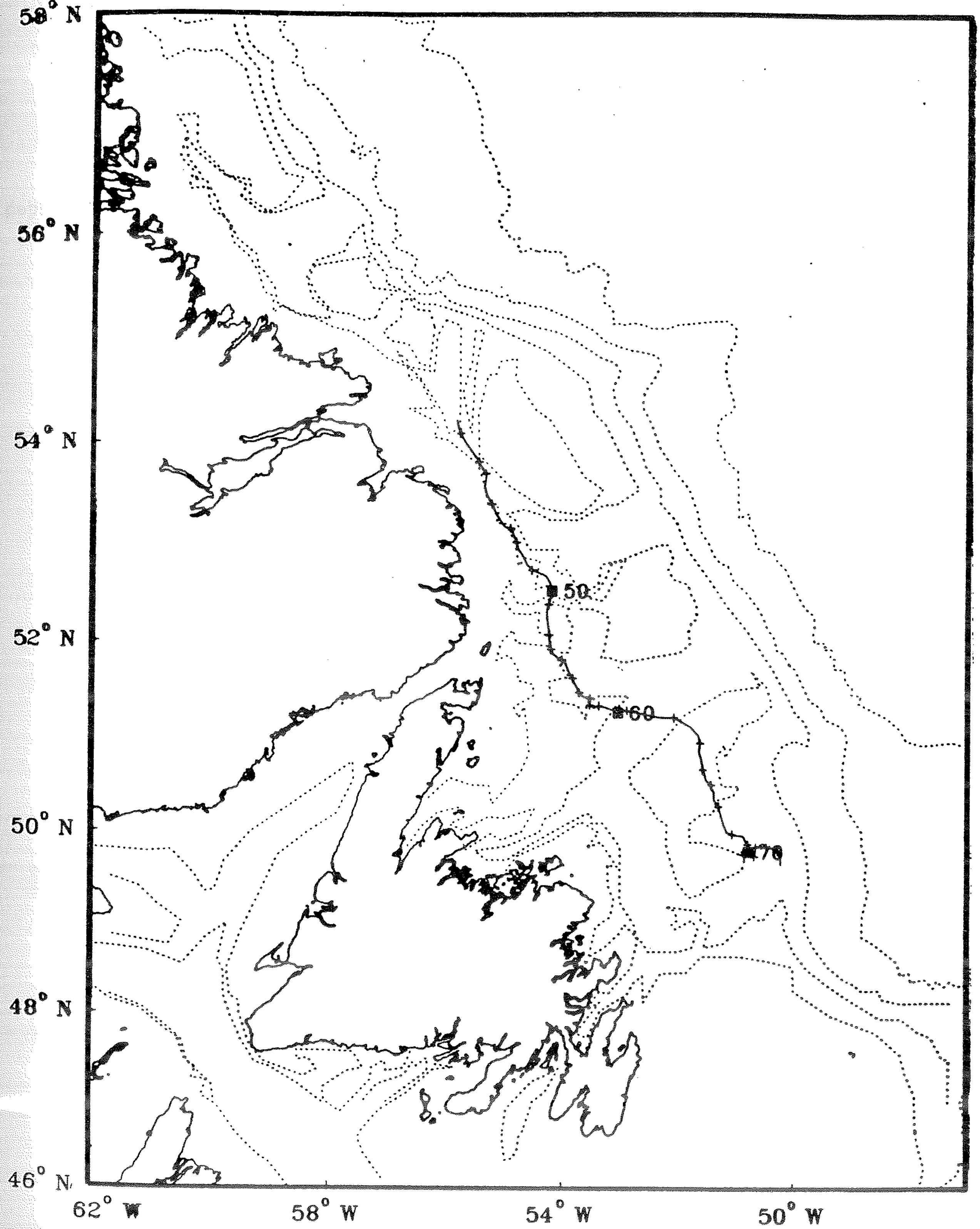
BUOY 10053 – 1992



BUOY 10054 - 1992



BUOY 10056 - 1992



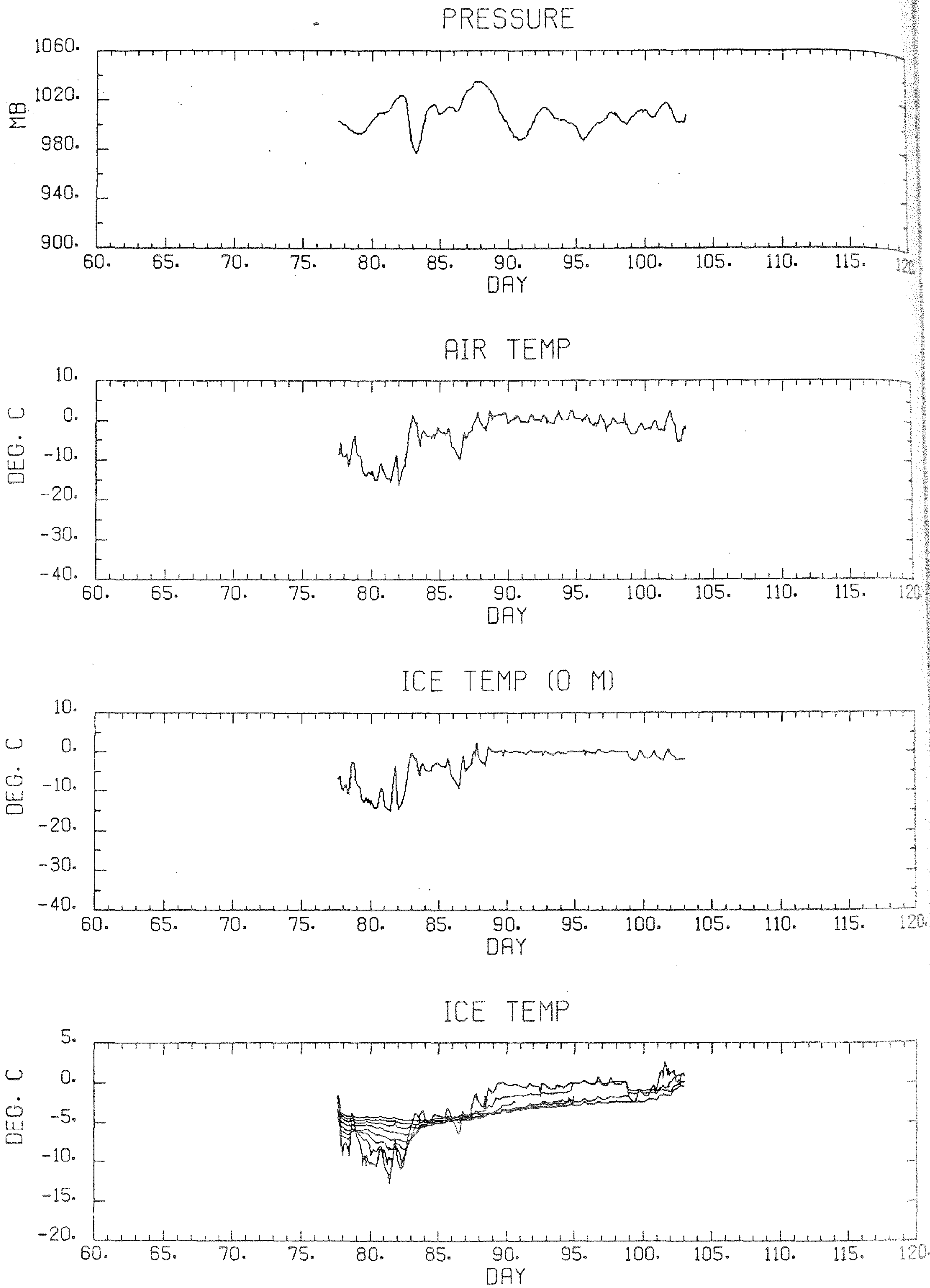
APPENDIX C: ICE BEACON ENVIRONMENTAL DATA

Time series plots of the environmental data collected by the beacons deployed on the mobile pack ice and the land-fast ice in Cartwright harbour.

Beacon ID #	Start Time*	End Time*	Type	Location
1052	77	102	Ice staff (SIMP)	Pack ice
1056	31	76	Ice staff (SIMP)	Sandwich Bay
1057	42	85	Ice staff (SIMP)	Pack ice
3320	42	77	Location	Pack ice
3321	43	88	Location	Pack ice
4757	31	65	Anemometer	Sandwich Bay
4758	66	96	Location (CMIB)	Pack ice
4759	68	103	Location (CMIB)	Pack ice
4760	66	111	Location (CMIB)	Pack ice
4763	77	92	Location (CMIB)	Pack ice
8647	76	115	Location	Pack ice
8649	77	137	Location	Pack ice
8667	76	133	Anemometer	Pack ice
10053	76	109	Temp. Chain	Pack ice
10054	43	73	Temp. Chain	Pack ice
10055	31	64	Temp. Chain	Pack ice
10056	42	75	Temp. Chain	Pack ice

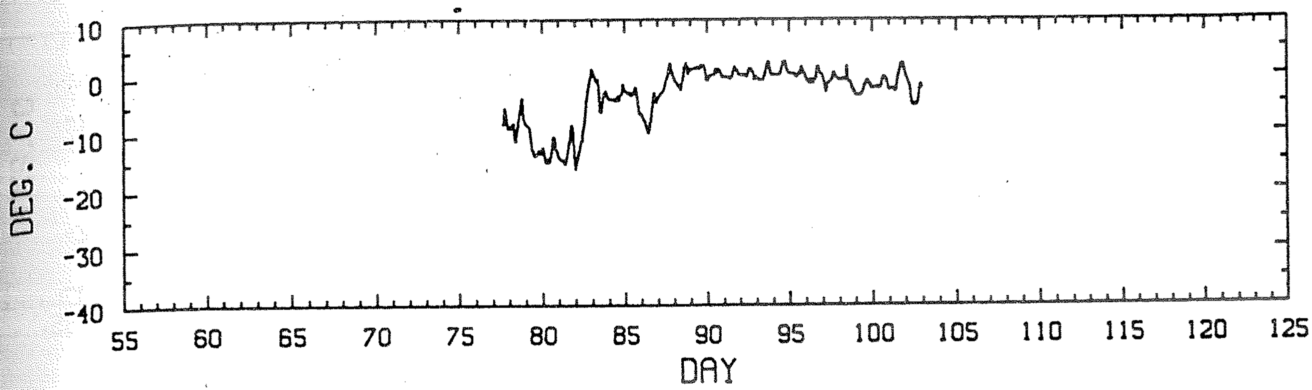
* times in 1992 calendar days.

BUOY 1052 - 1992

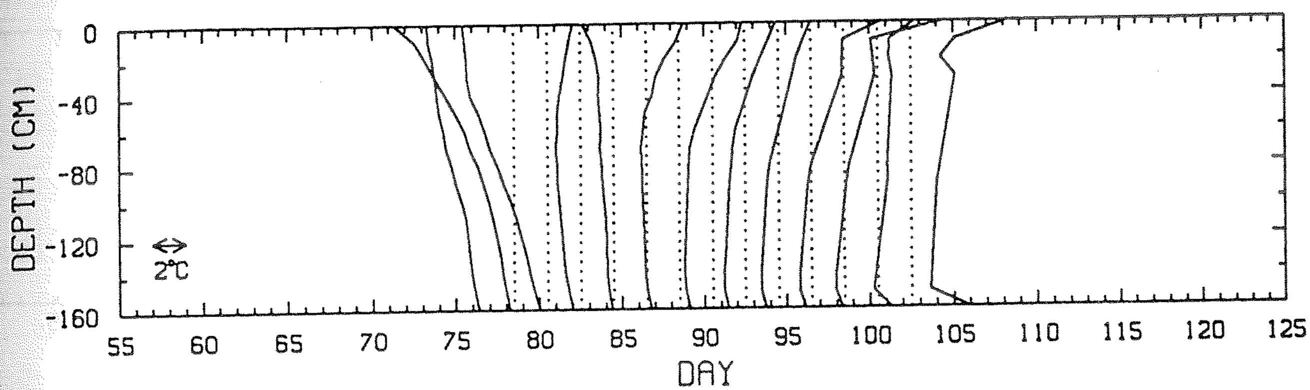


BUOY 1052 - 1992

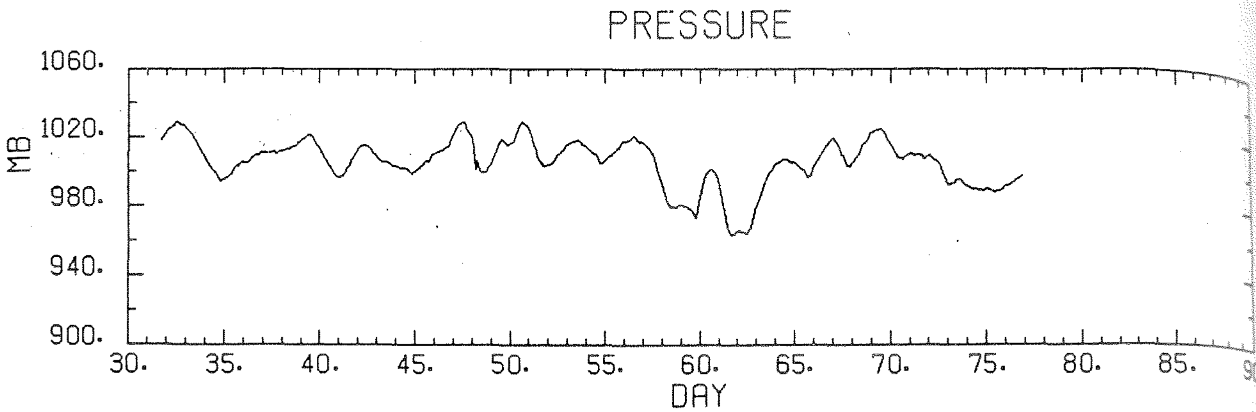
AIR TEMP

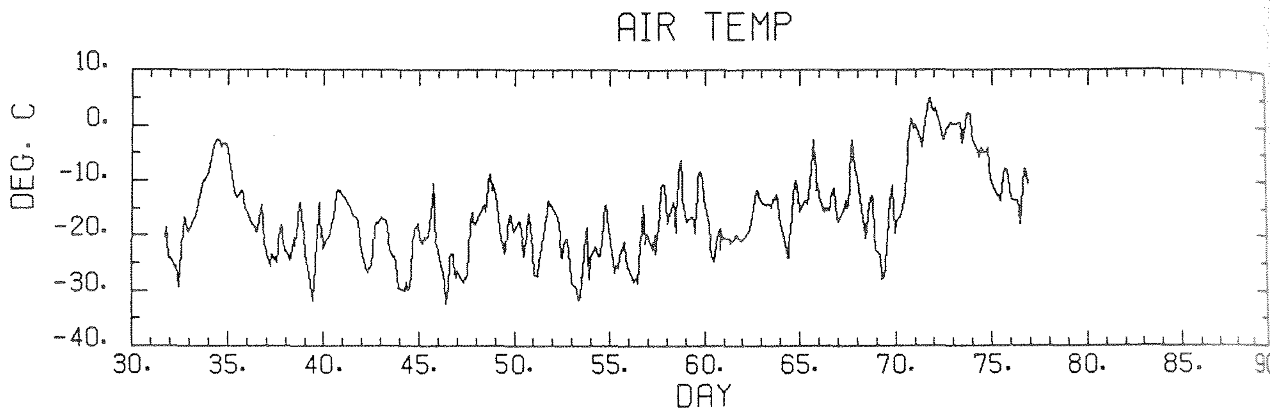


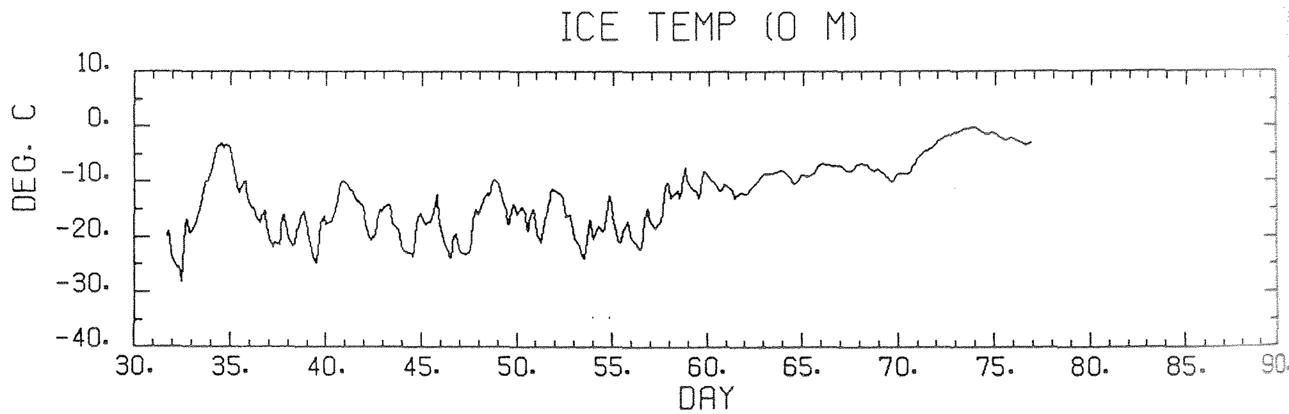
ICE TEMPERATURE (DEG. C)

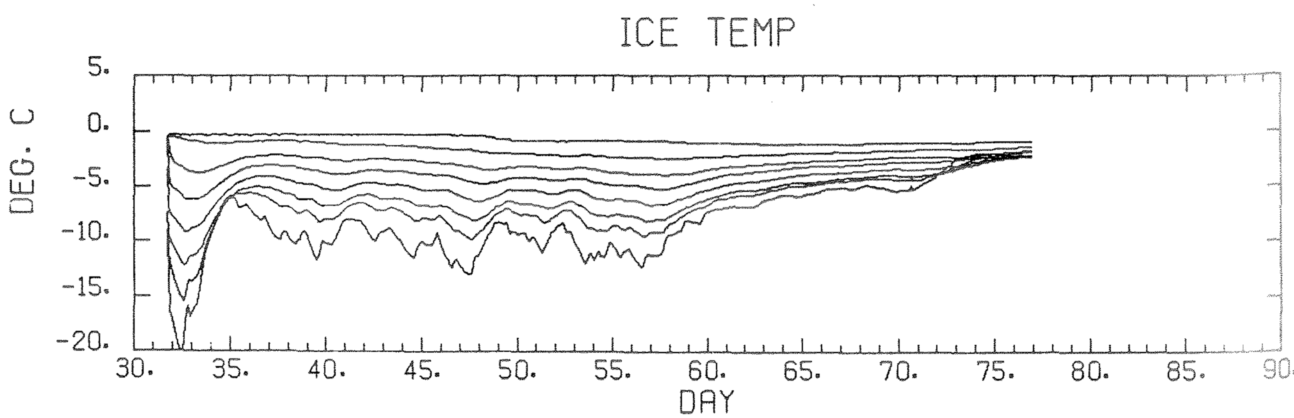


BUOY 1056 - 1992



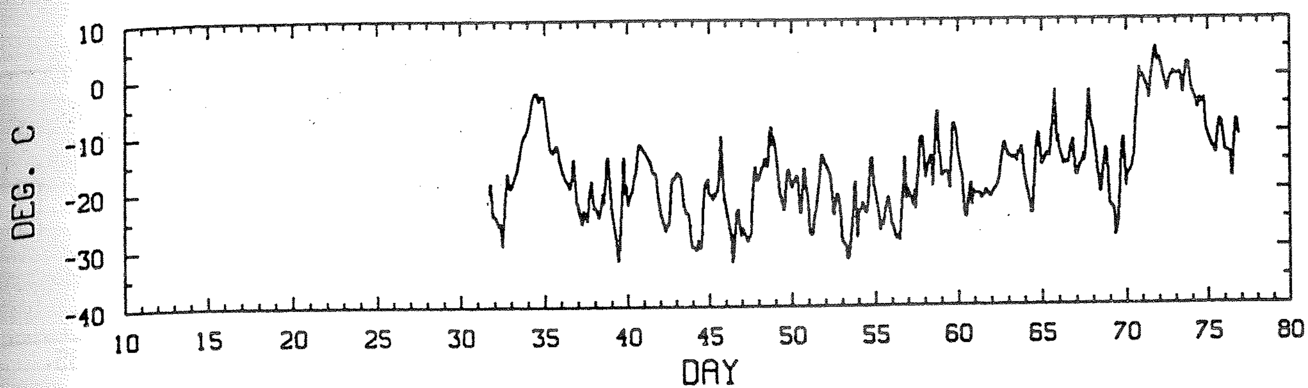




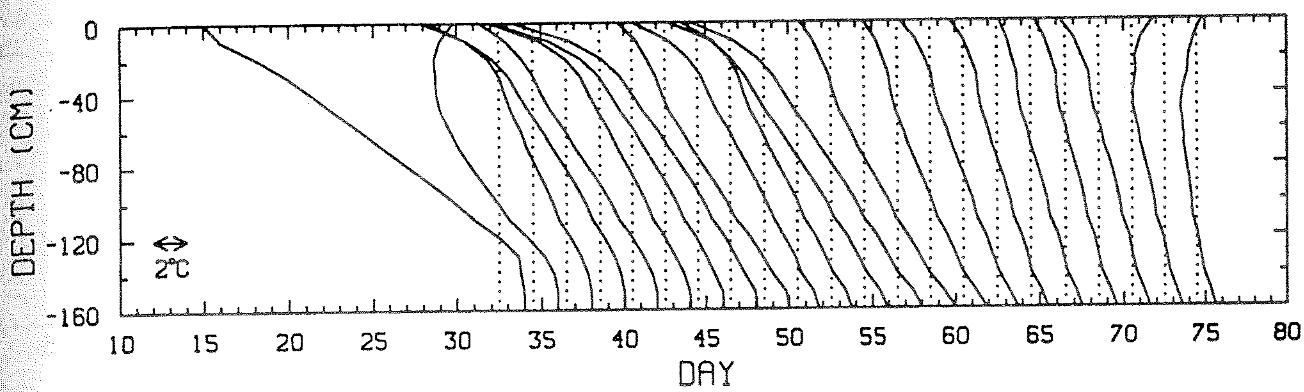


BUOY 1056 - 1992

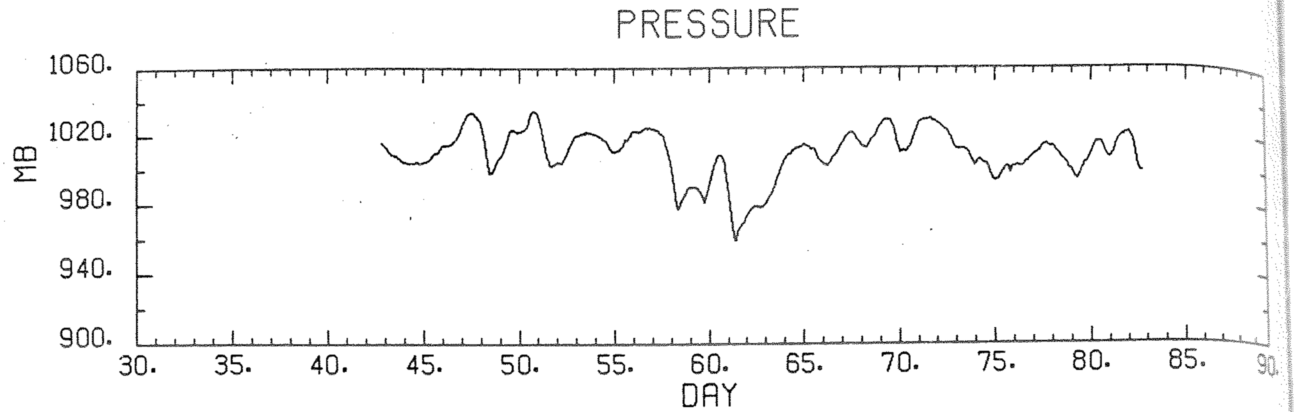
AIR TEMP

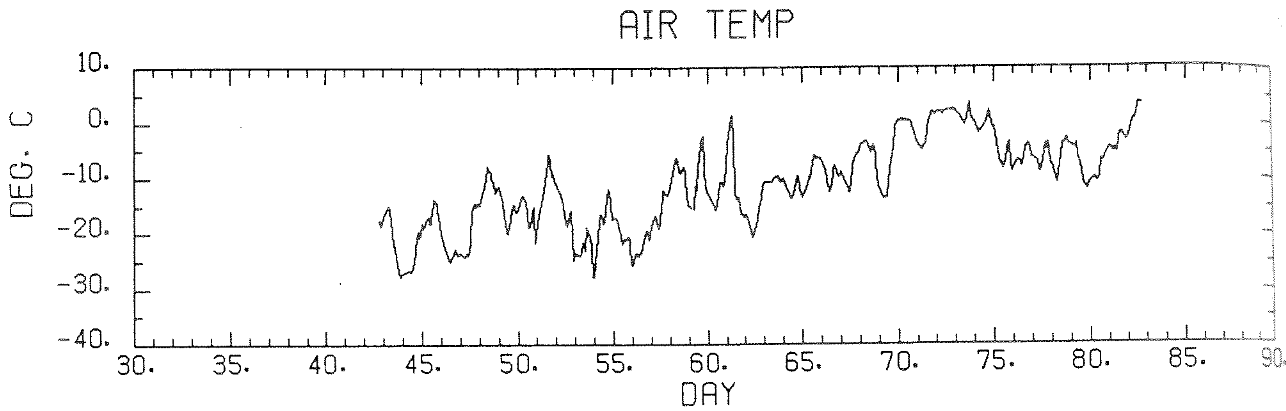


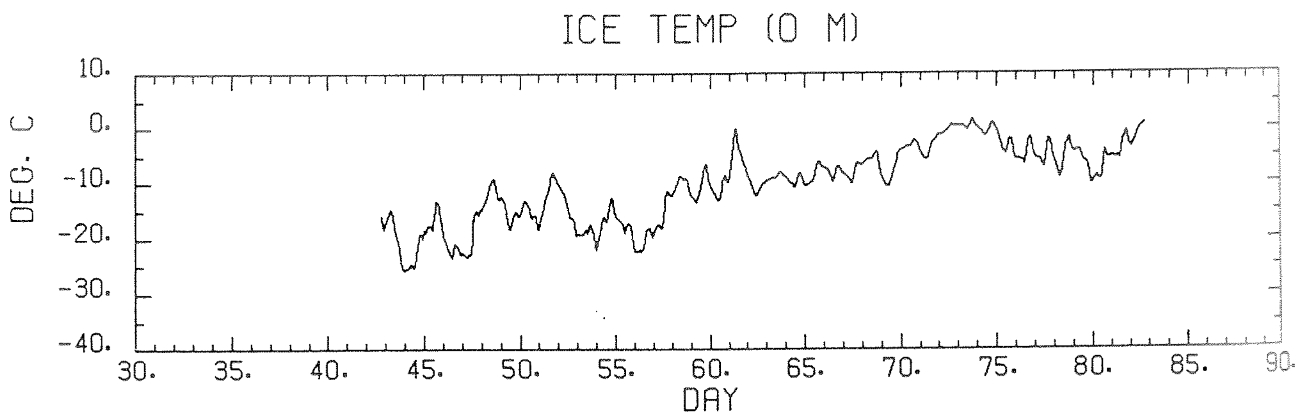
ICE TEMPERATURE (DEG. C)

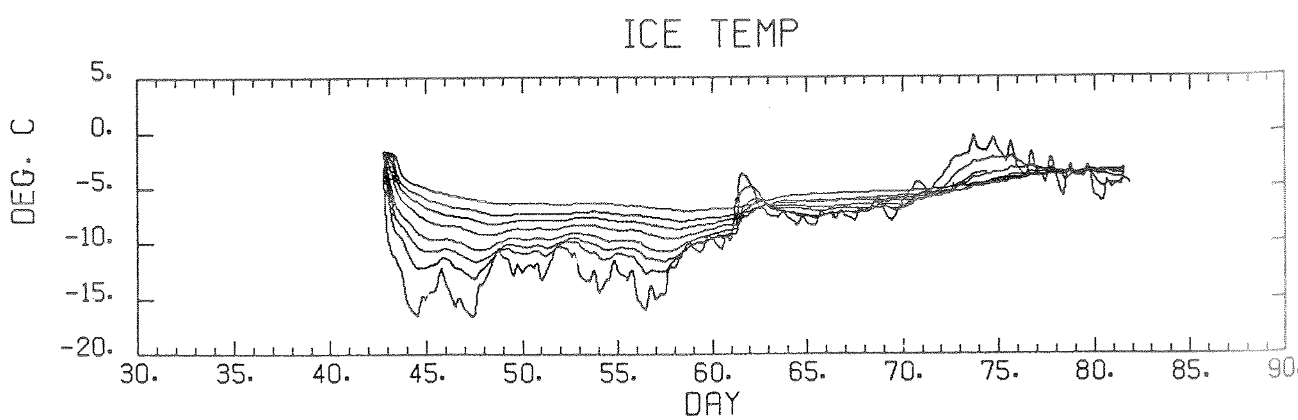


BUOY 1057 - 1992



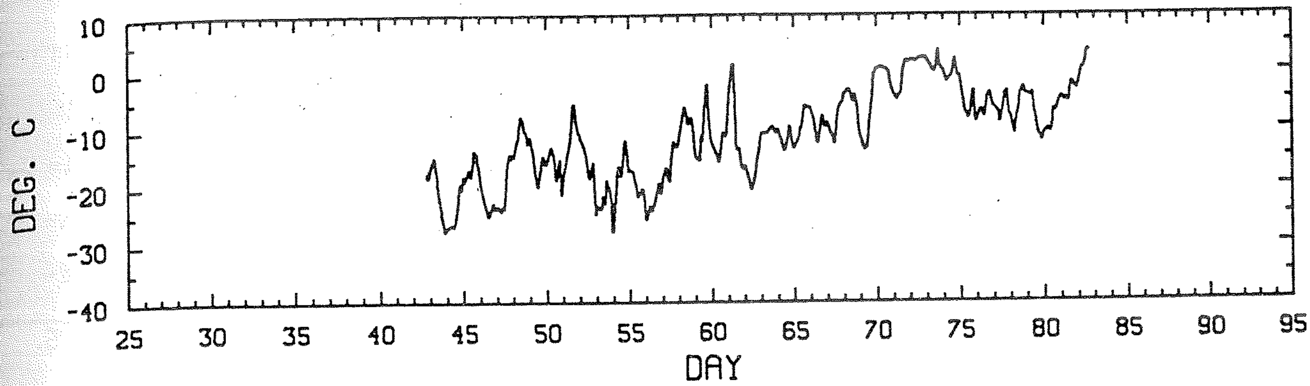




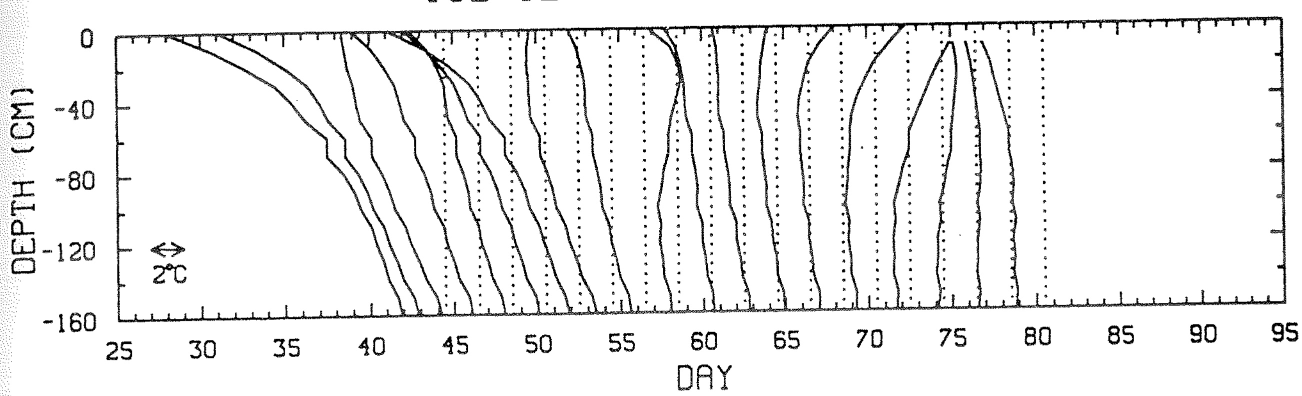


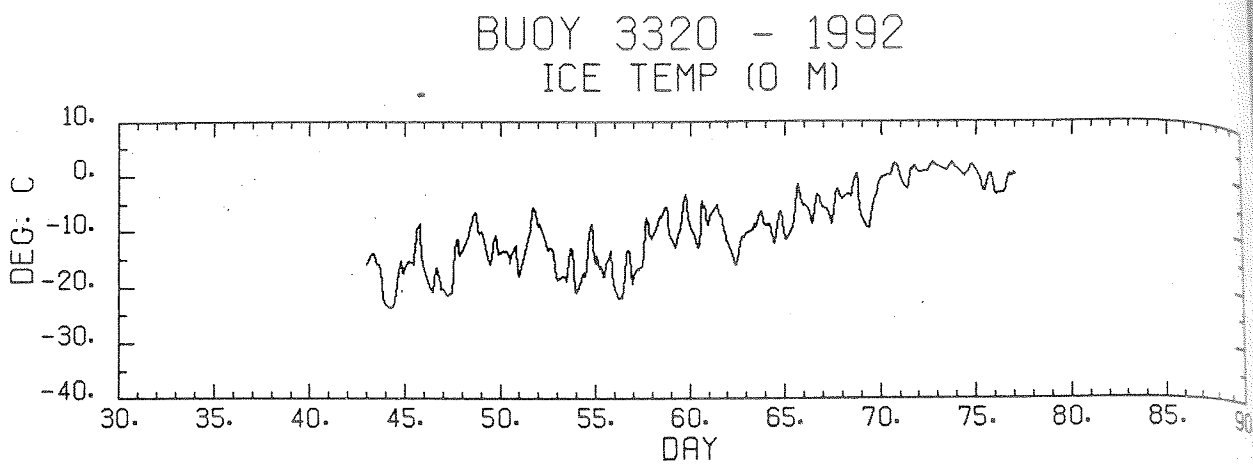
BUOY 1057 - 1992

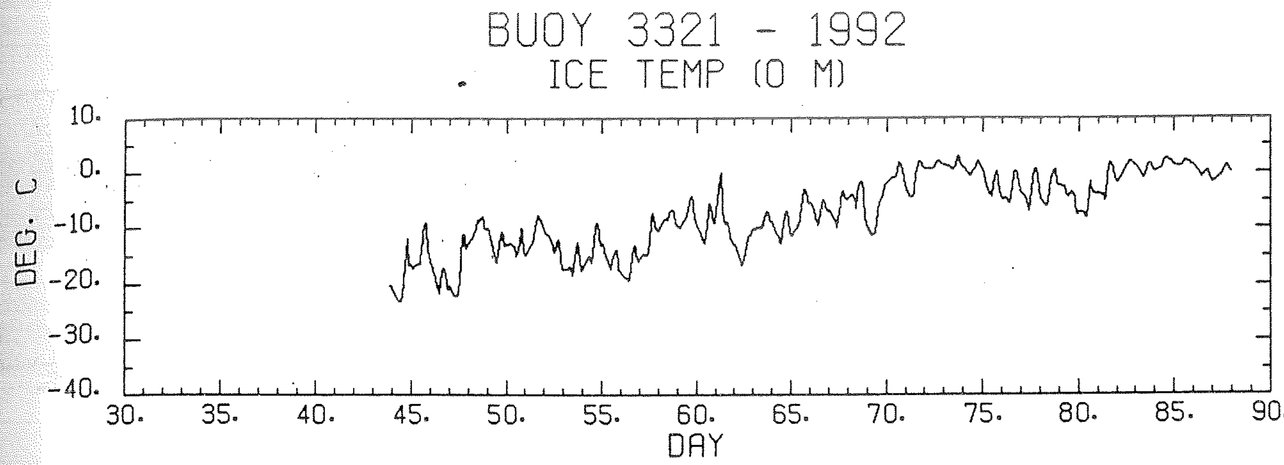
AIR TEMP



ICE TEMPERATURE (DEG. C)

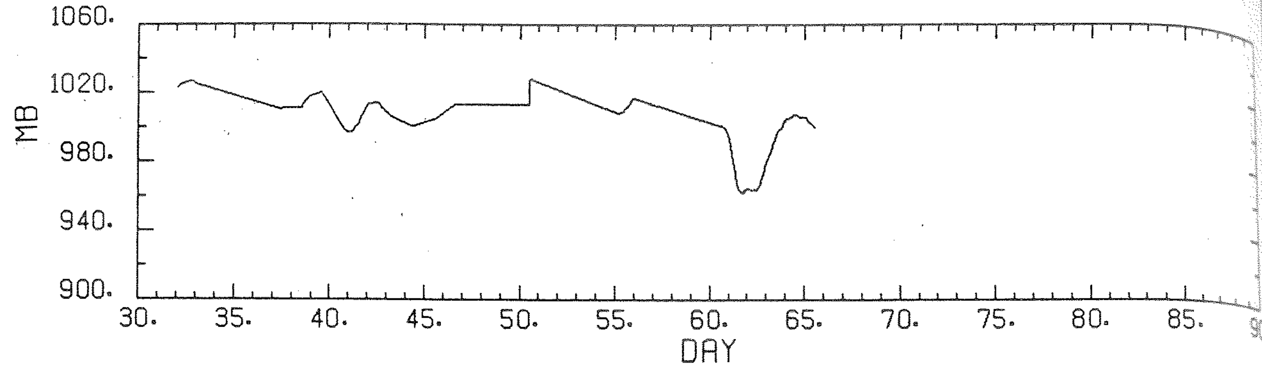



BUOY 3320 - 1992
ICE TEMP (0 M)
DEG: C
10.
0.
-10.
-20.
-30.
-40.
30.
35.
40.
45.
50.
55.
60.
65.
70.
75.
80.
85.
90.
DAY

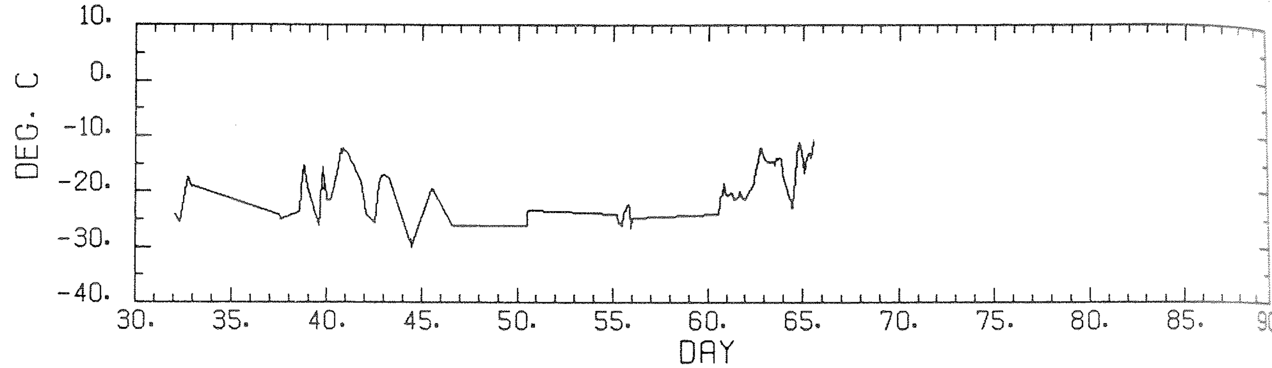

BUOY 3321 - 1992
ICE TEMP (0 M)
DEG. C
10.
0.
-10.
-20.
-30.
-40.
30.
35.
40.
45.
50.
55.
60.
65.
70.
75.
80.
85.
90.
DAY

BUOY 4757 - 1992

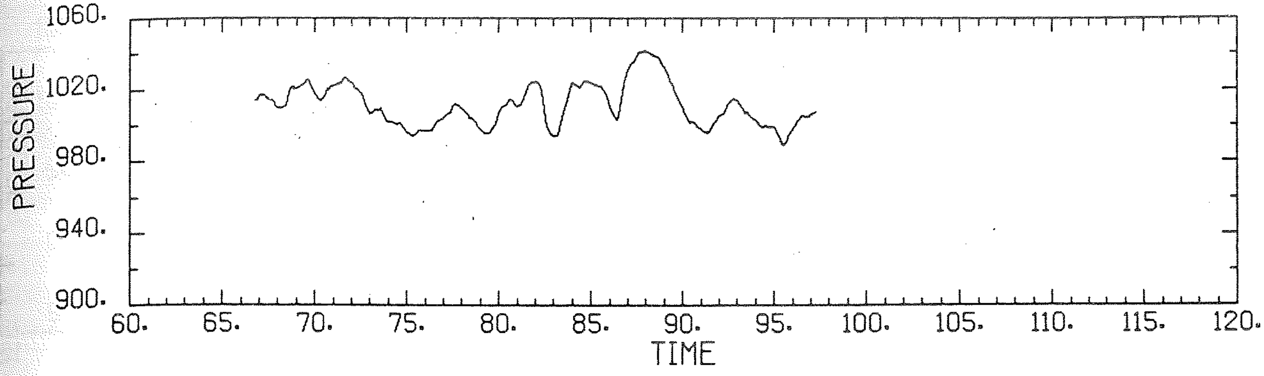
PRESSURE

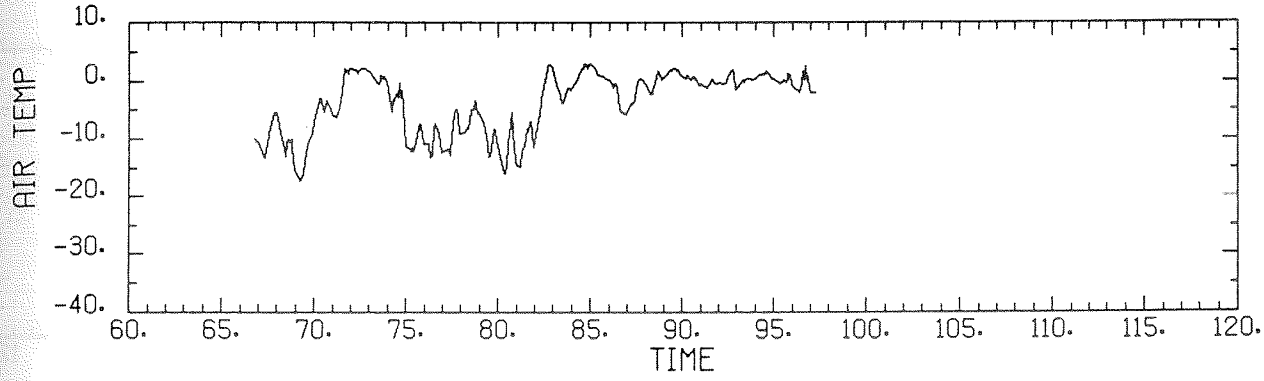


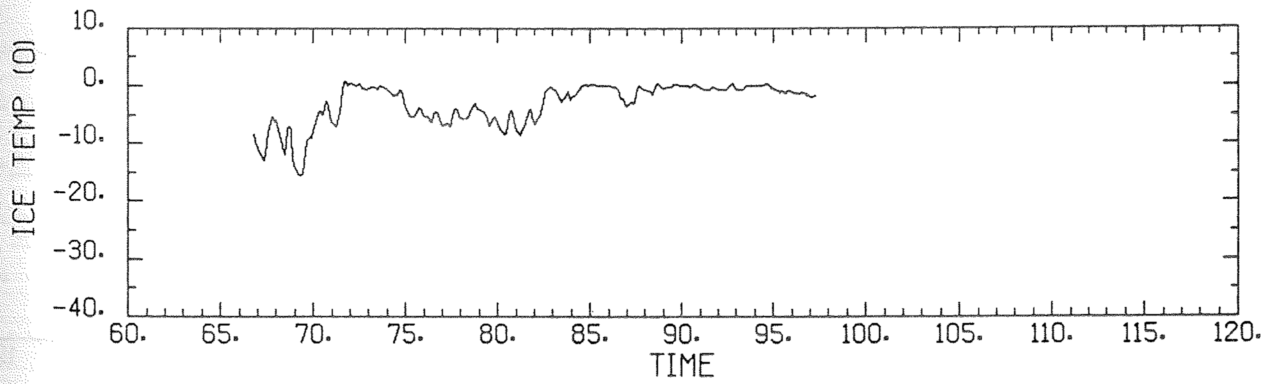
AIR TEMP



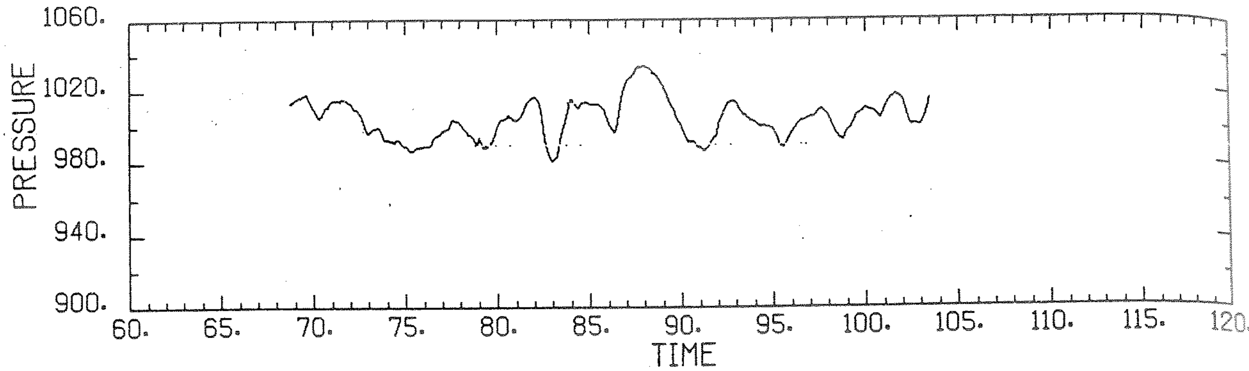
BUOY 4758 - 1992

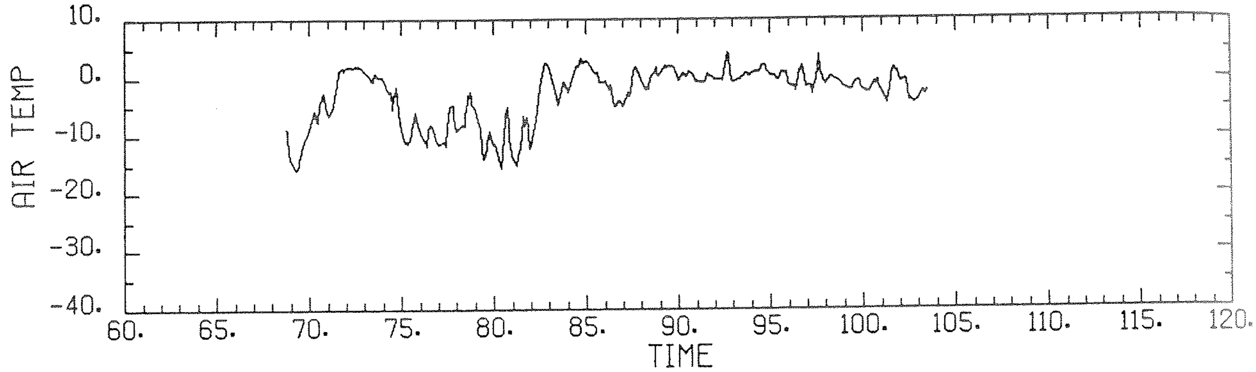


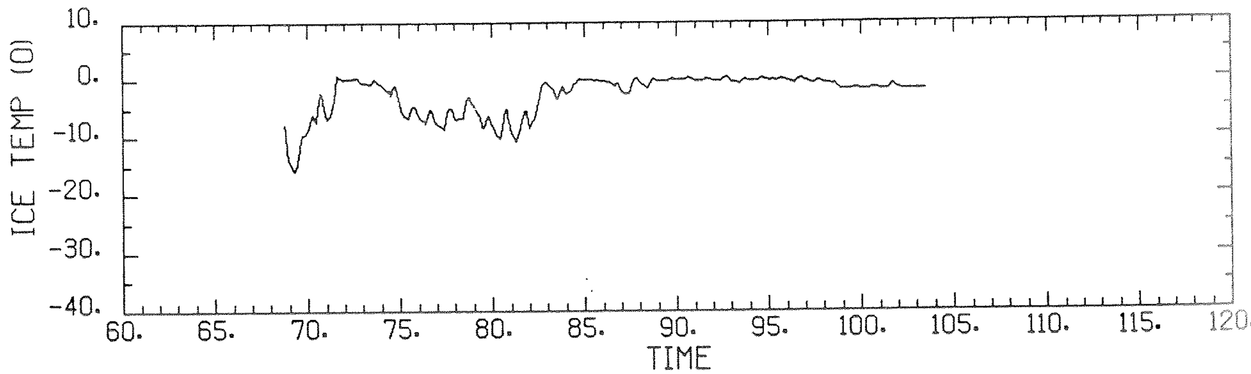




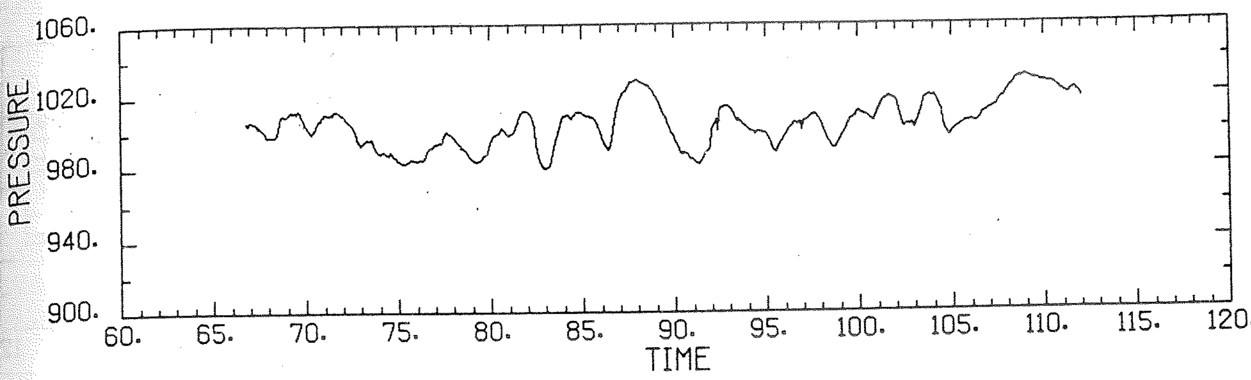
BUOY 4759 - 1992

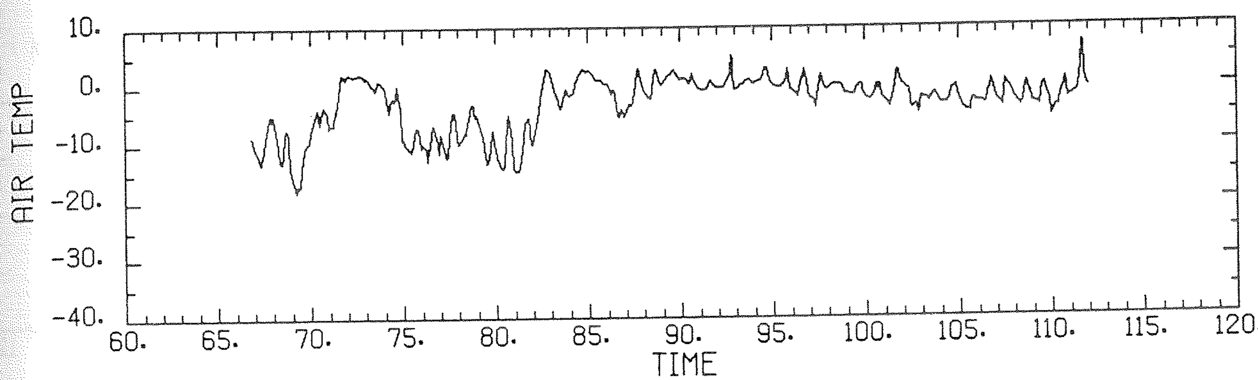


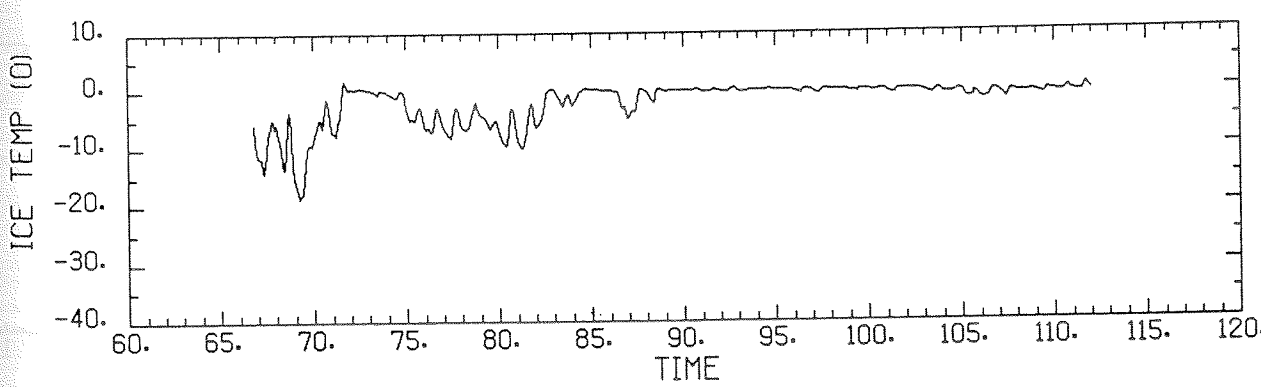




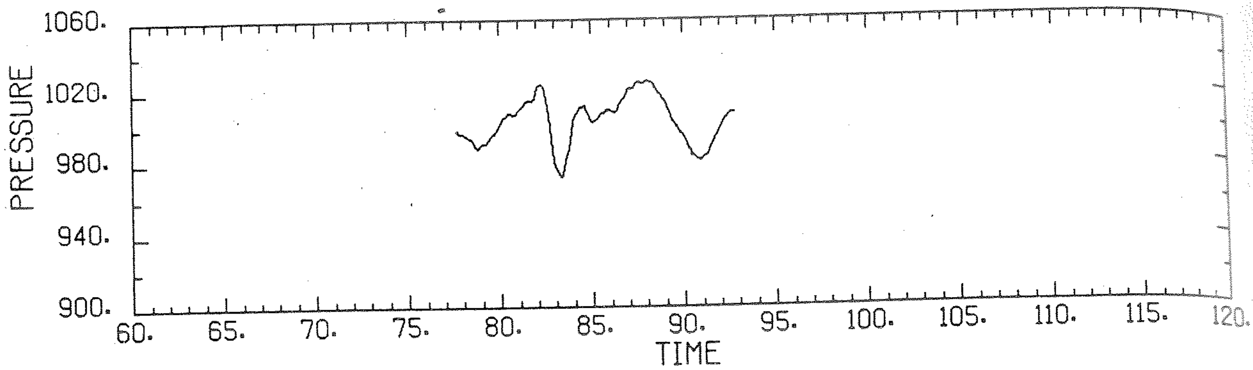
BUOY 4760 - 1992

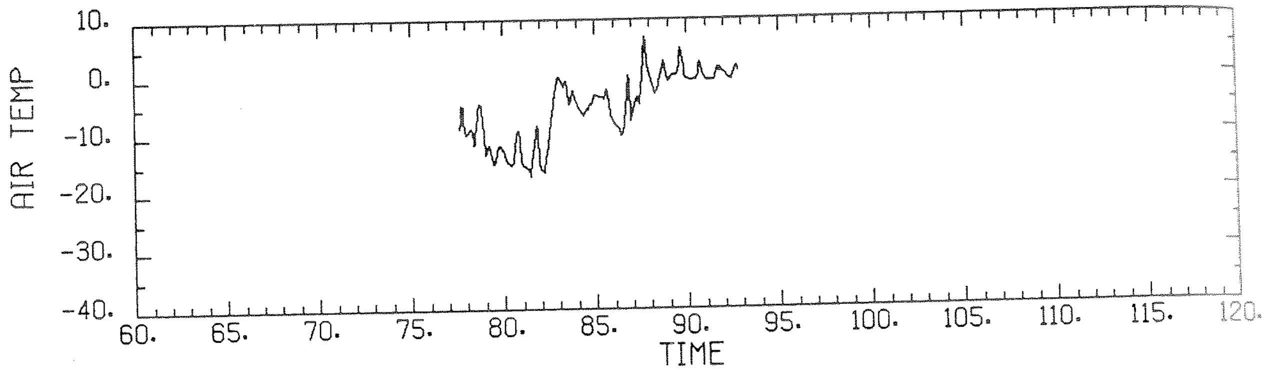


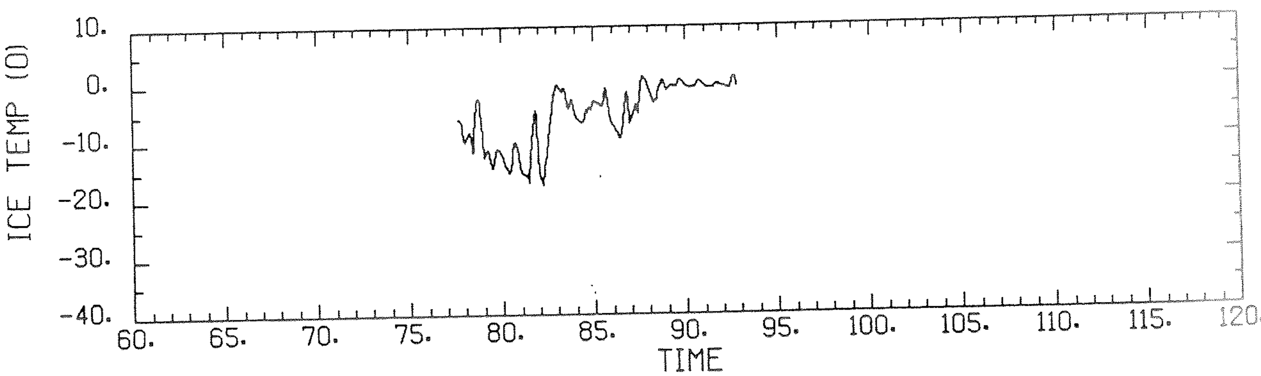




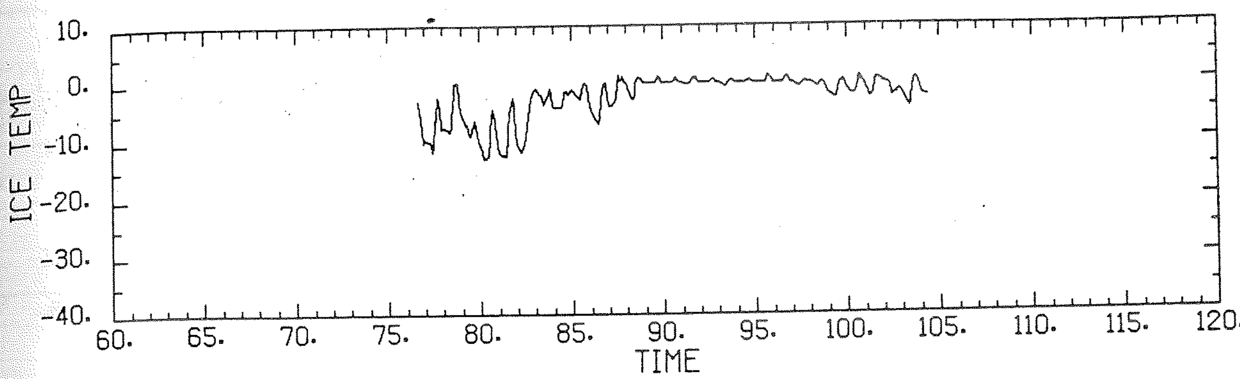
BUOY 4763 - 1992







BUOY 8647 - 1992



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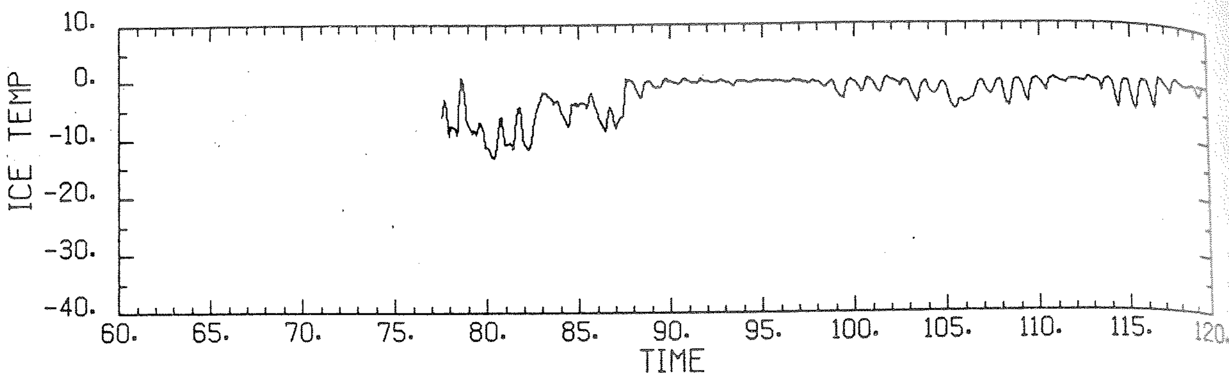
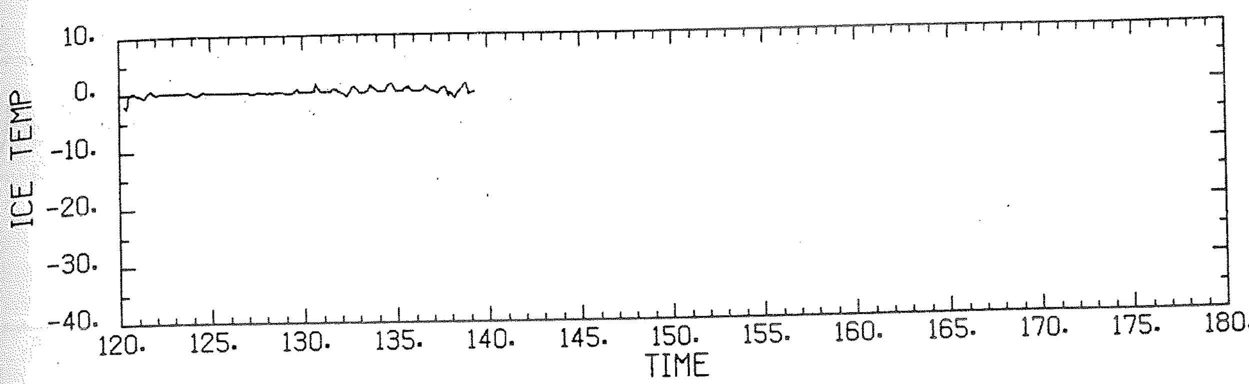
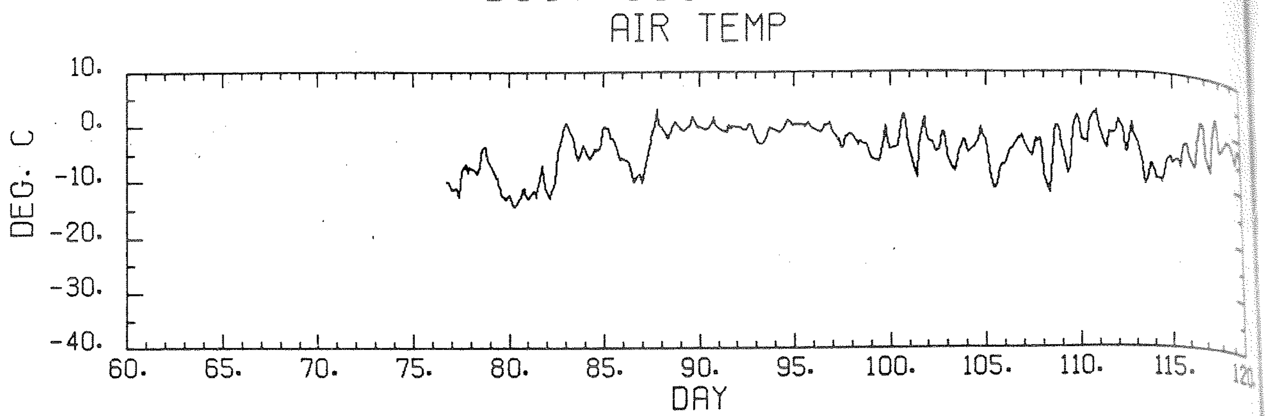
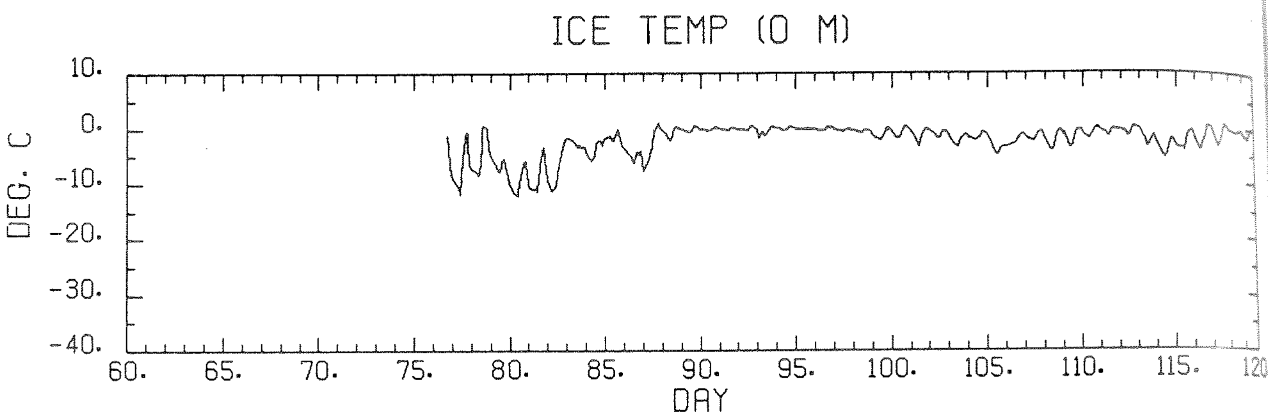


BUOY 8649 - 1992



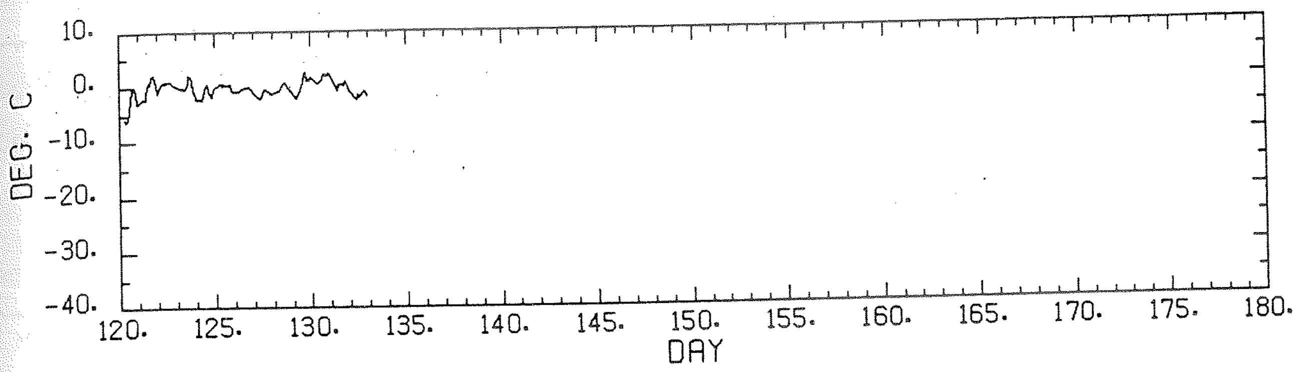
BUOY 8667 - 1992



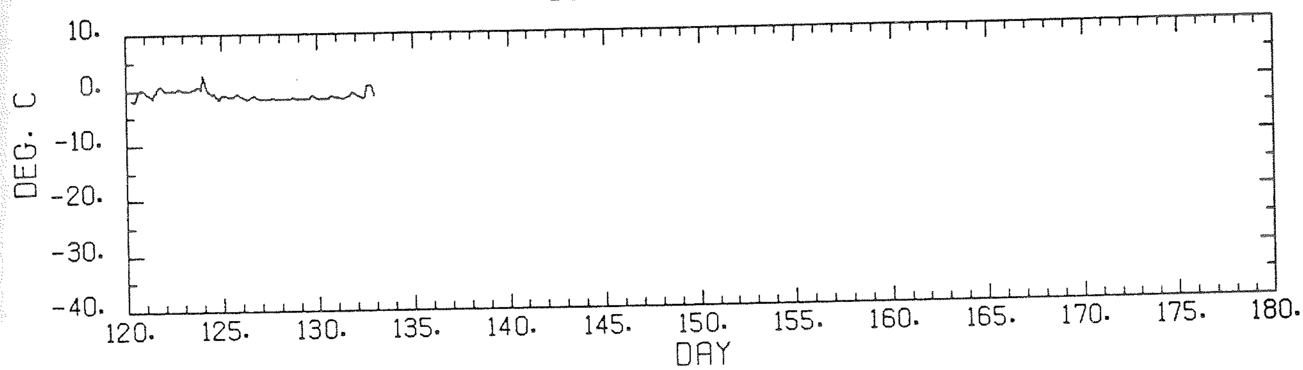


BUOY 8667 - 1992

AIR TEMP

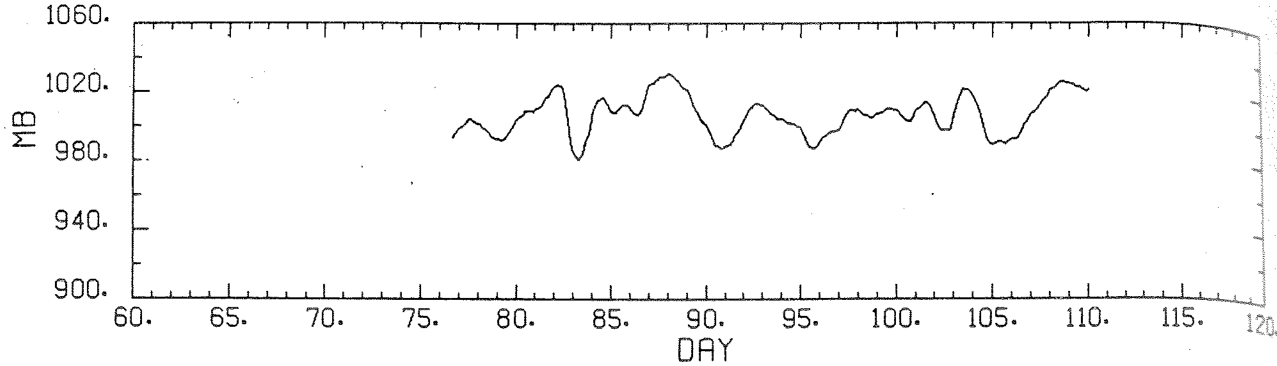


ICE TEMP (0 M)

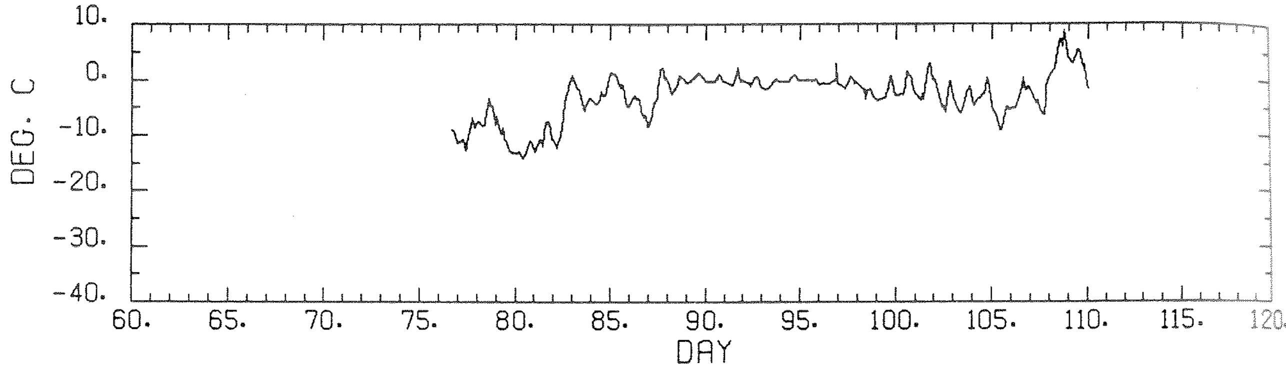


BUOY 10053 - 1992

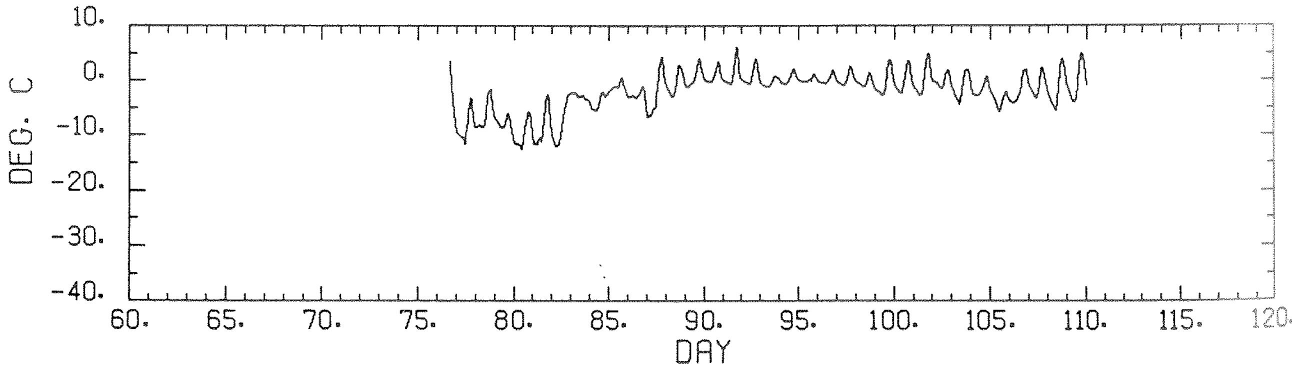
PRESSURE



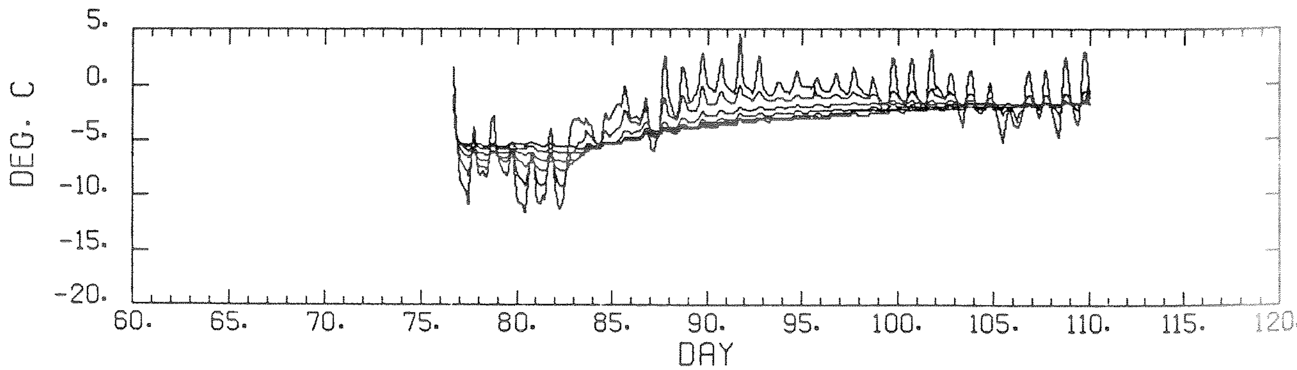
AIR TEMP

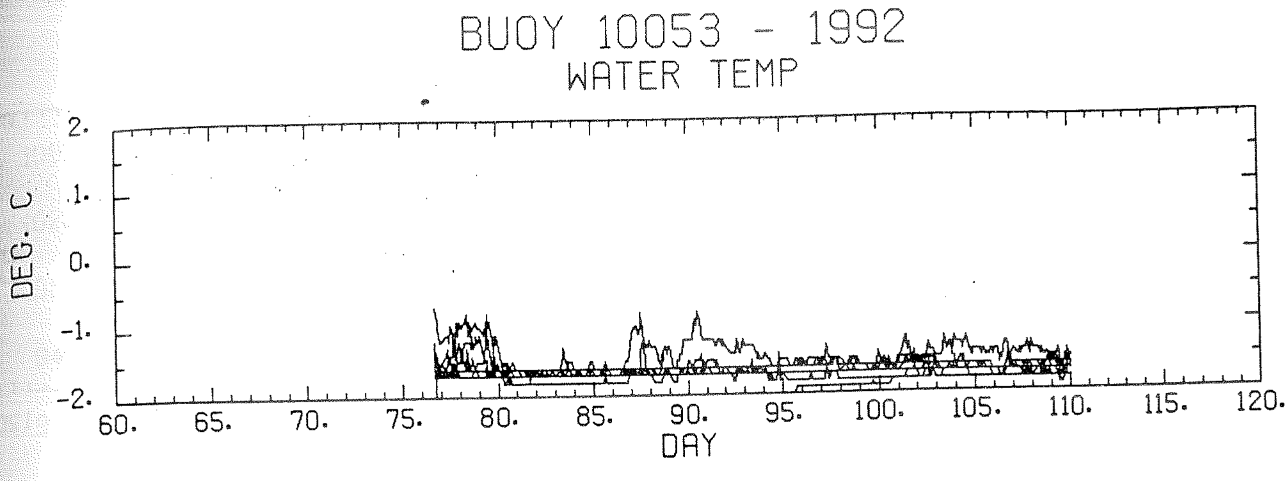


ICE TEMP (0 M)



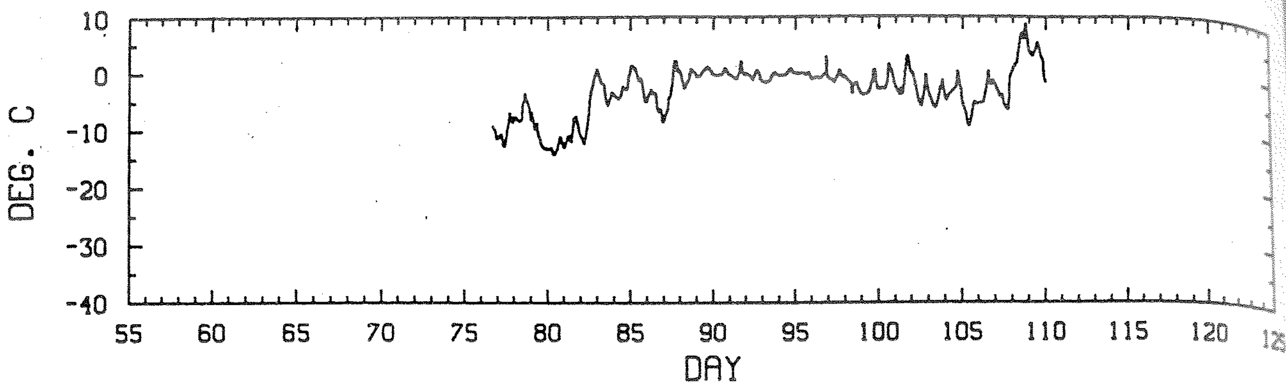
ICE TEMP



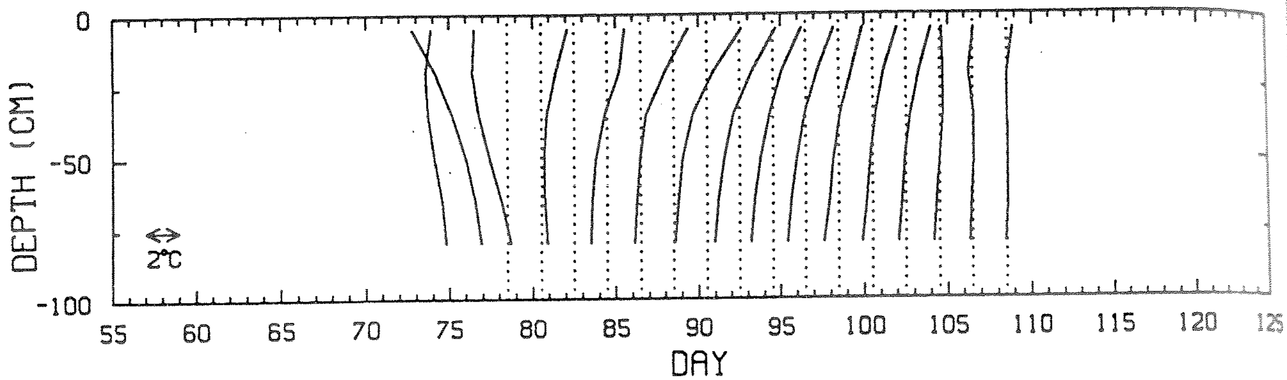

BUOY 10053 - 1992
WATER TEMP
DEG. C
2.
1.
0.
-1.
-2.
60.
65.
70.
75.
80.
85.
90.
95.
100.
105.
110.
115.
120.
DAY

BUOY 10053 - 1992

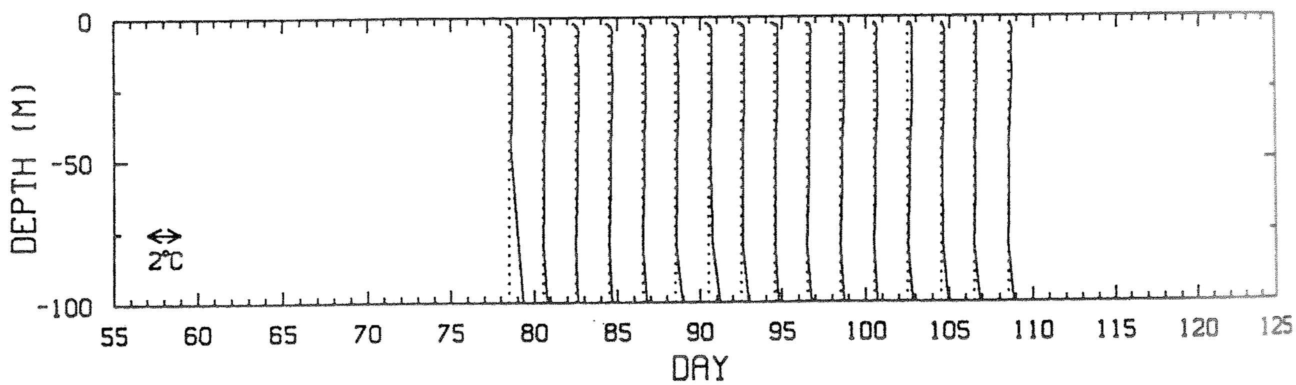
AIR TEMP



ICE TEMPERATURE (DEG. C)

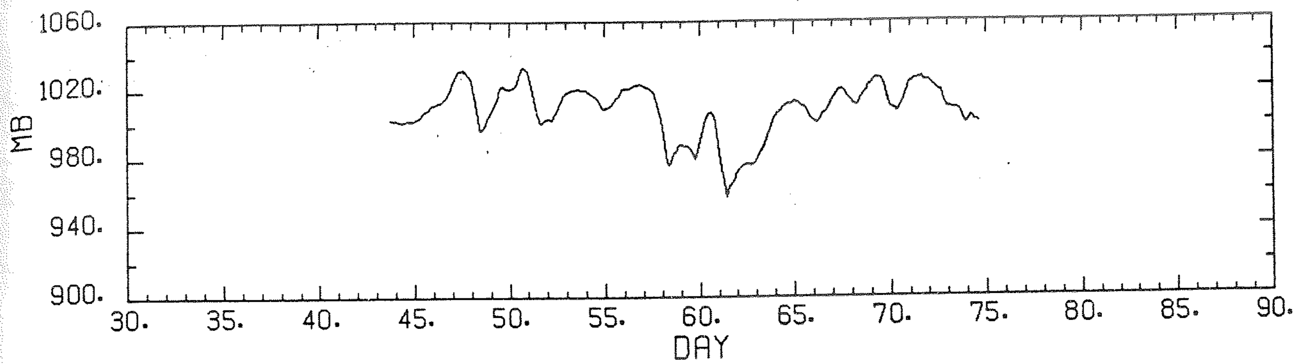


WATER TEMPERATURE (DEG. C)

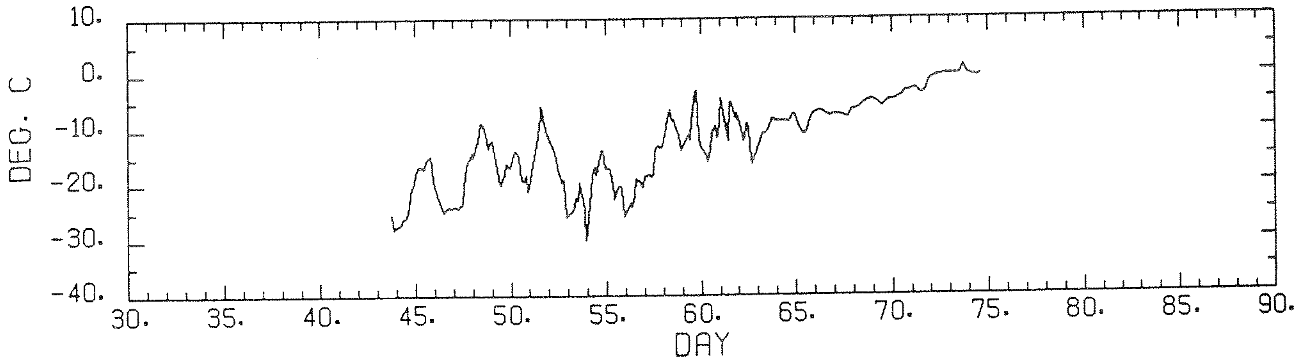


BUOY 10054 - 1992

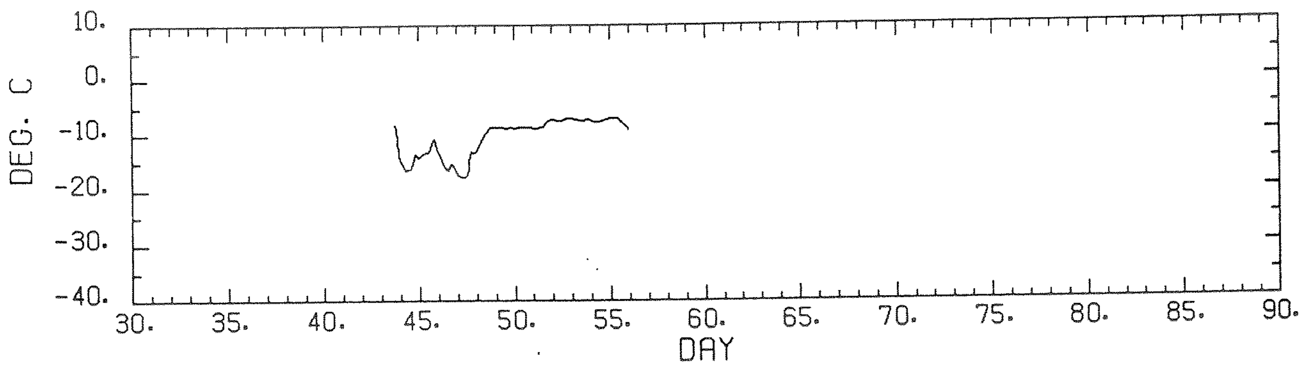
PRESSURE



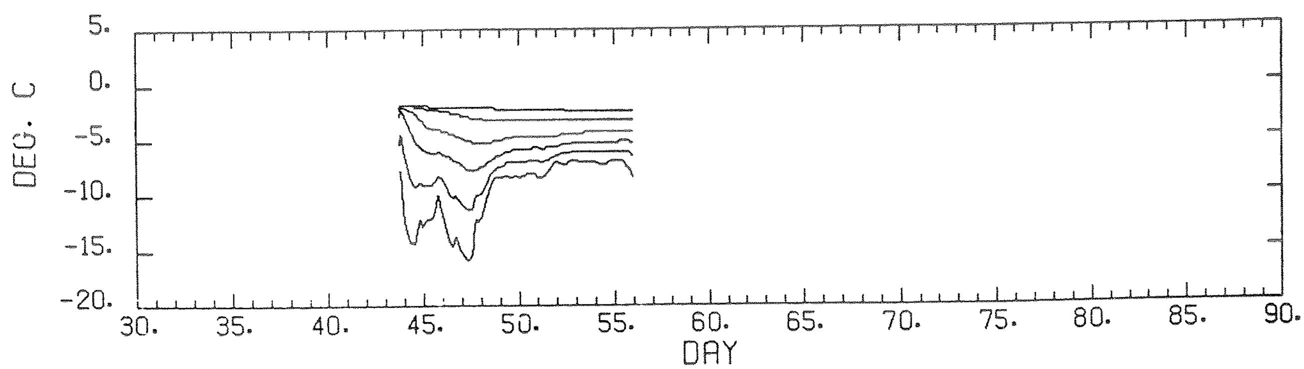
AIR TEMP



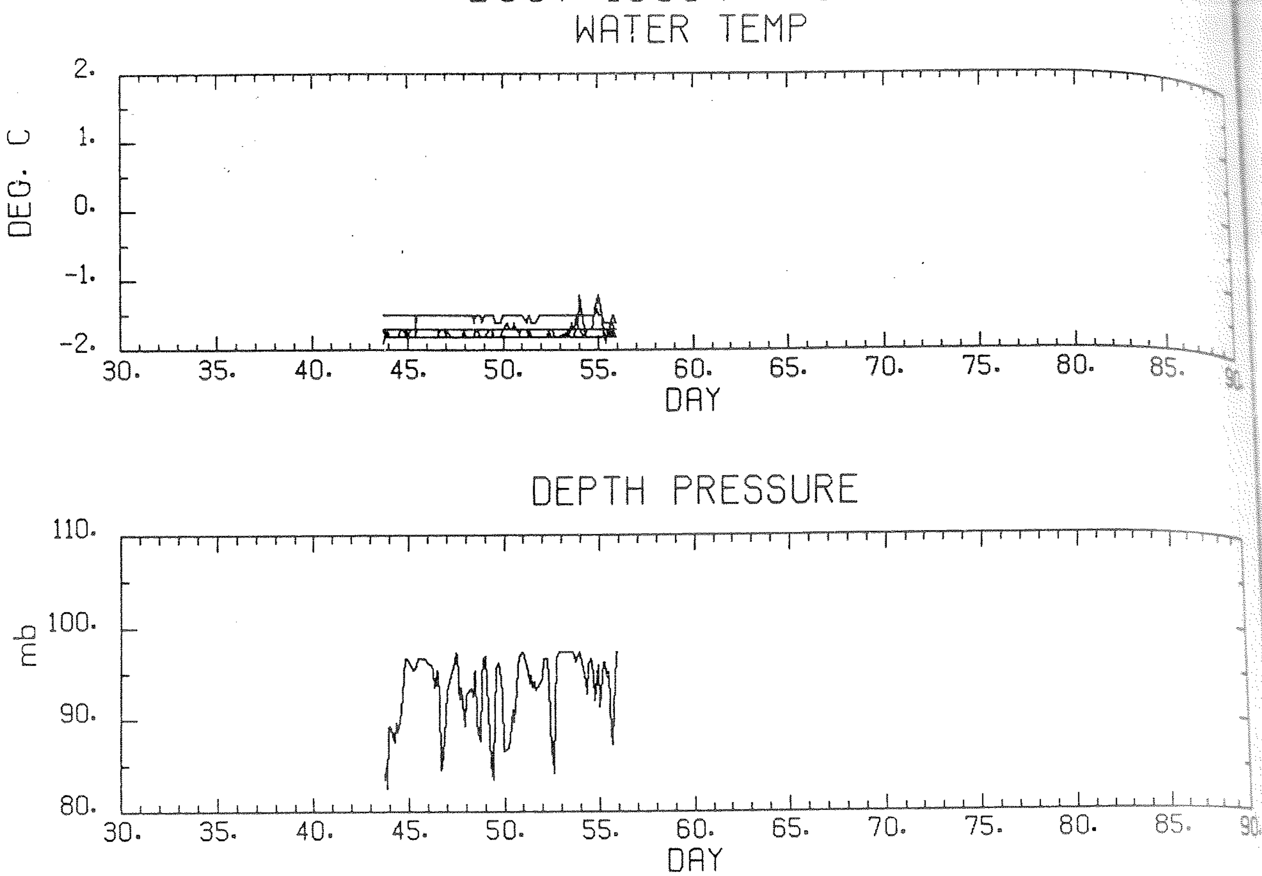
ICE TEMP (0 M)



ICE TEMP

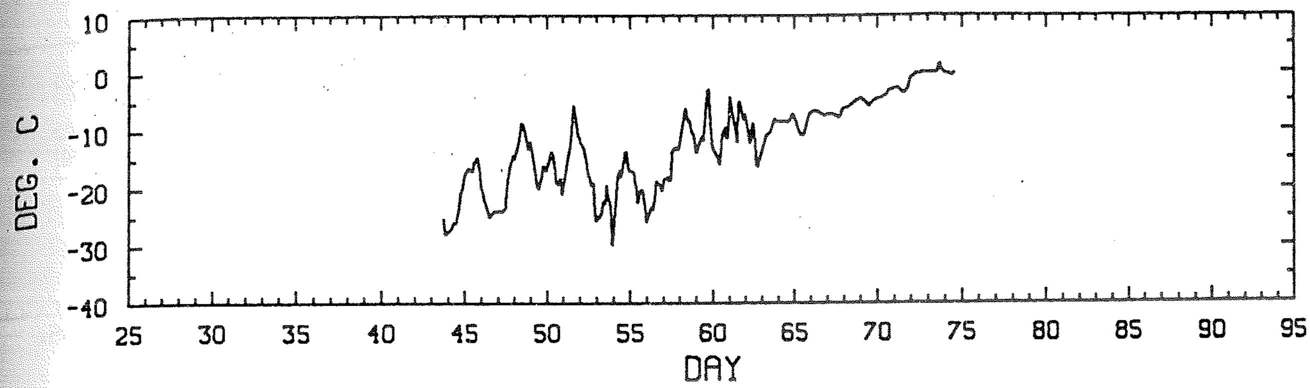


BUOY 10054 - 1992

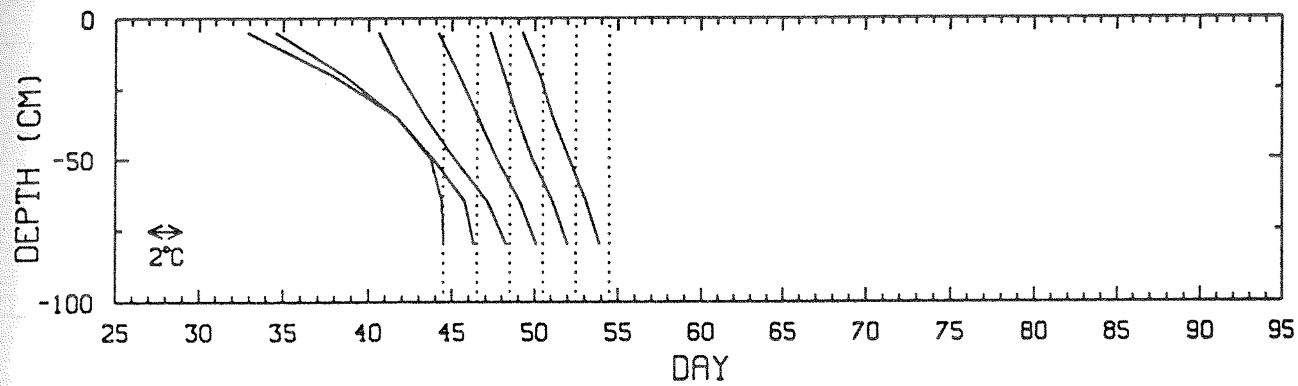


BUOY 10054 - 1992

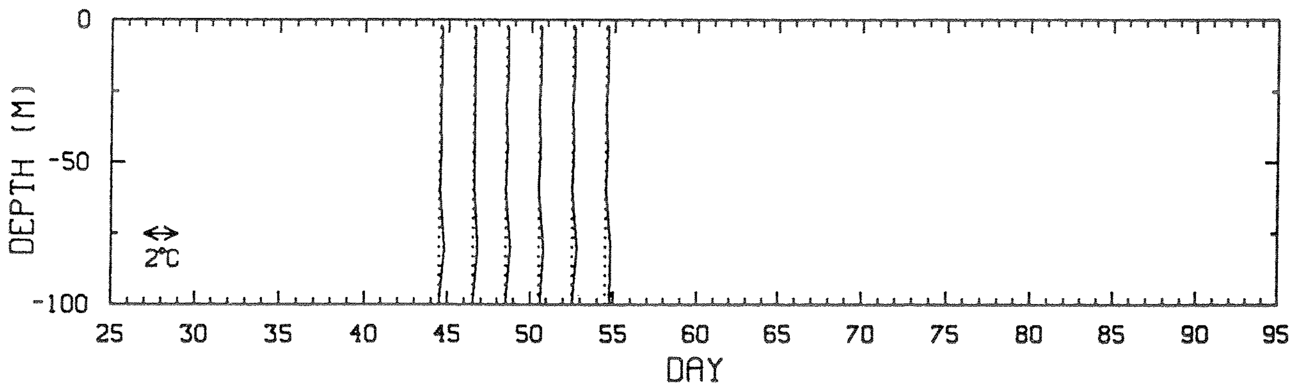
AIR TEMP



ICE TEMPERATURE (DEG. C)

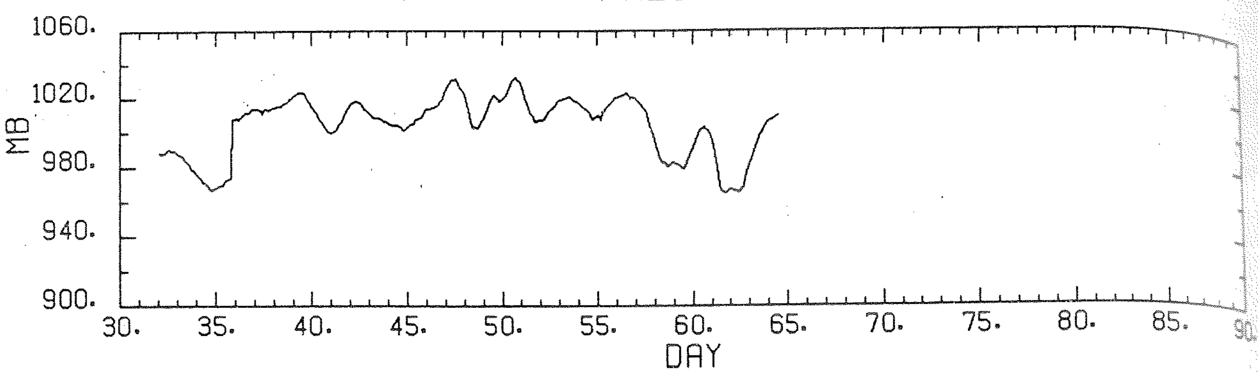


WATER TEMPERATURE (DEG. C)

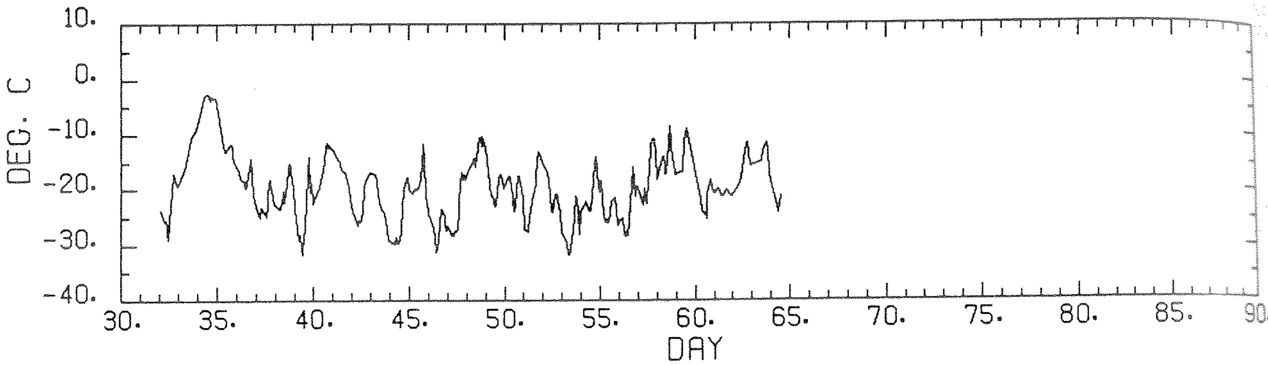


BUOY 10055 - 1992

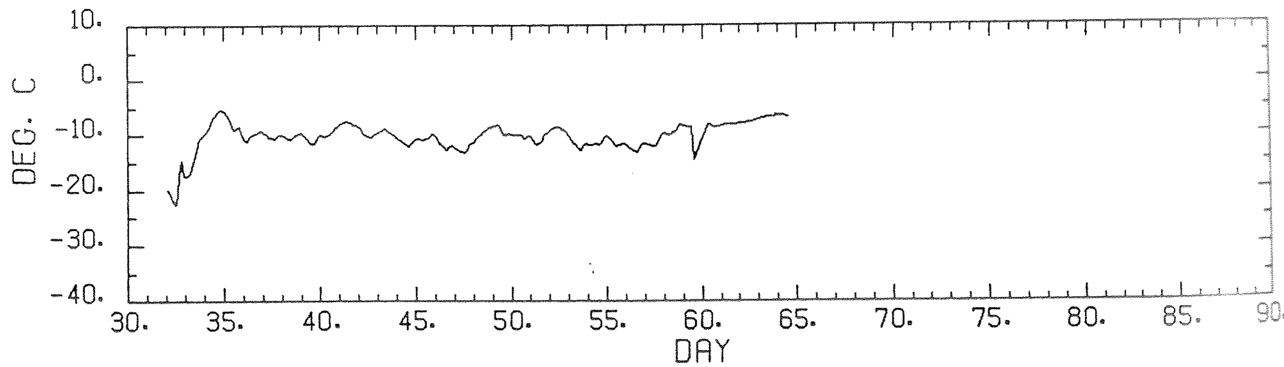
PRESSURE



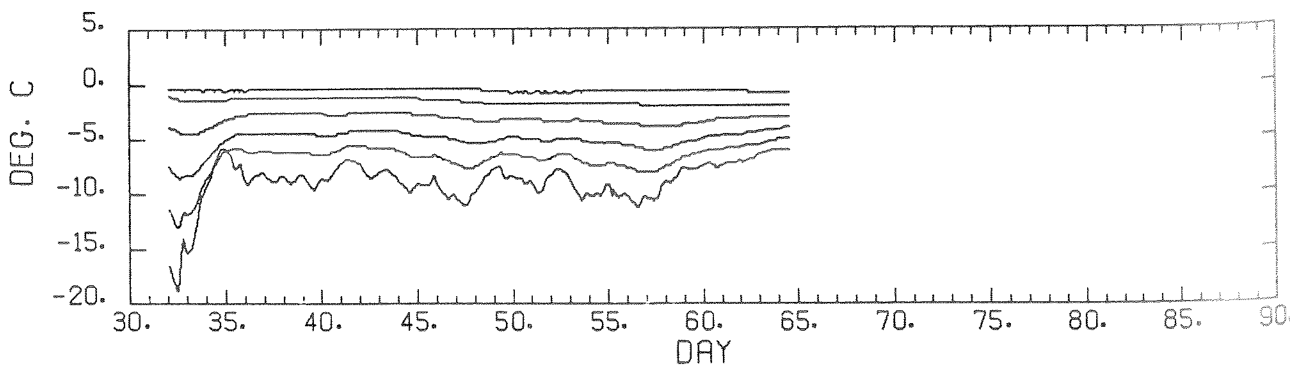
AIR TEMP



ICE TEMP (0 M)

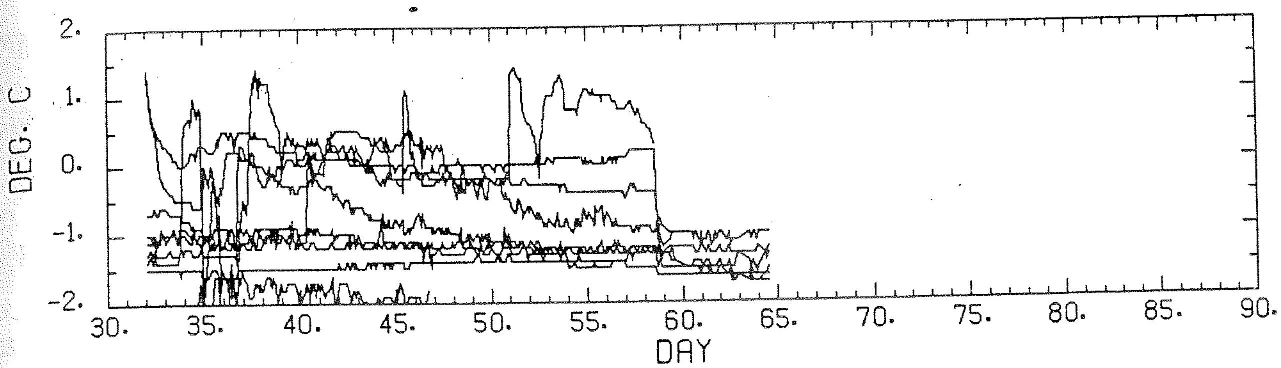


ICE TEMP

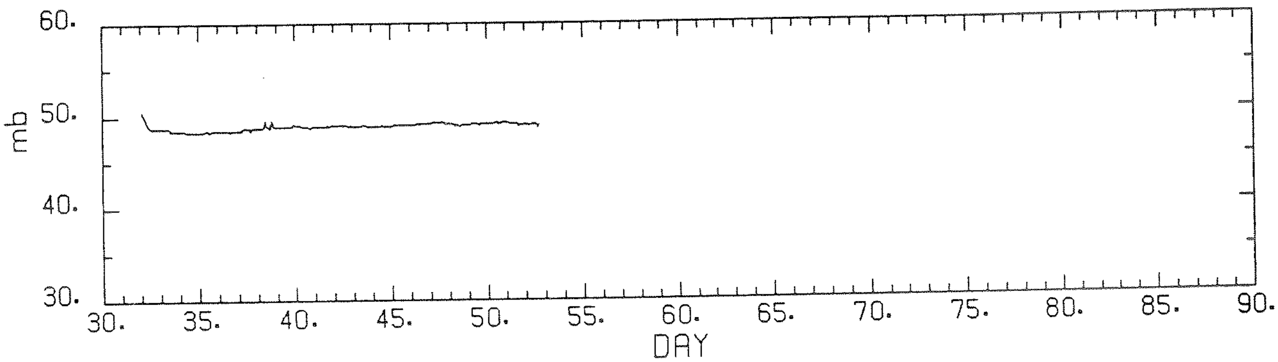


BUOY 10055 - 1992

WATER TEMP

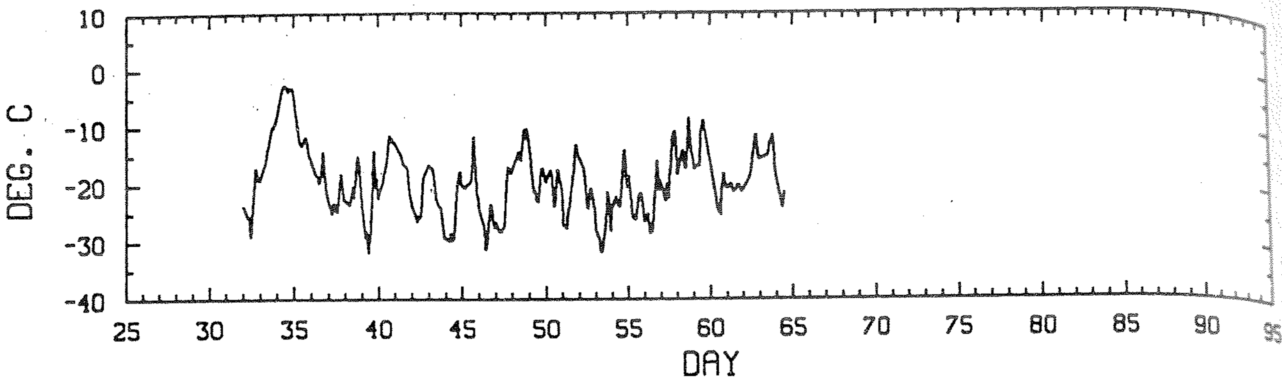


DEPTH PRESSURE

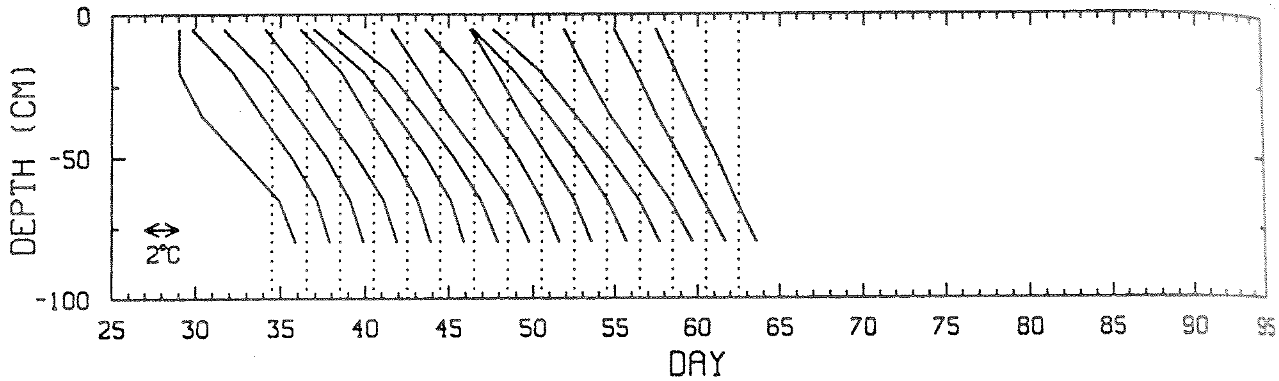


BUOY 10055 - 1992

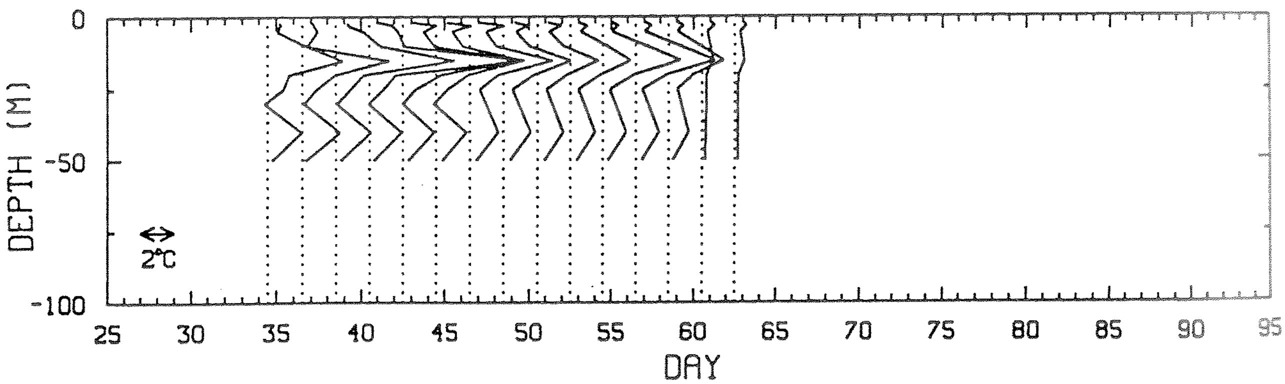
AIR TEMP



ICE TEMPERATURE (DEG. C)

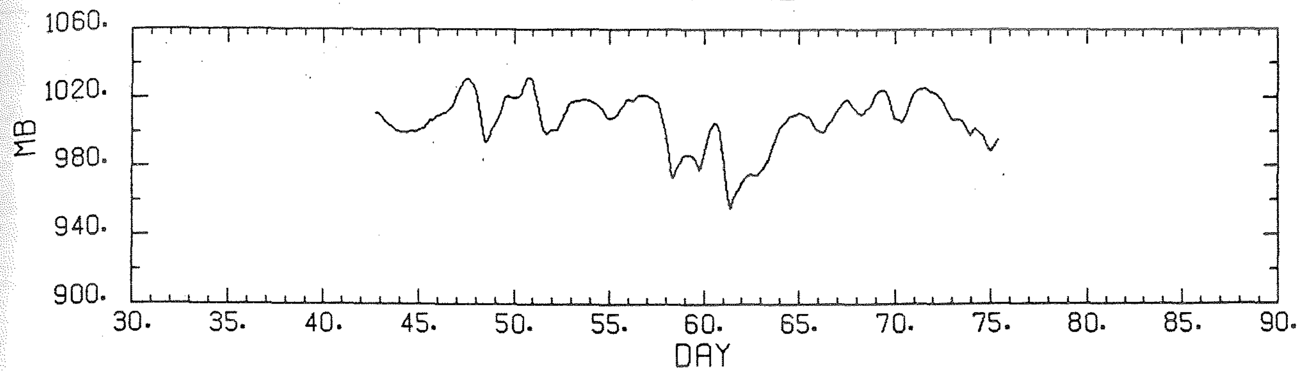


WATER TEMPERATURE (DEG. C)

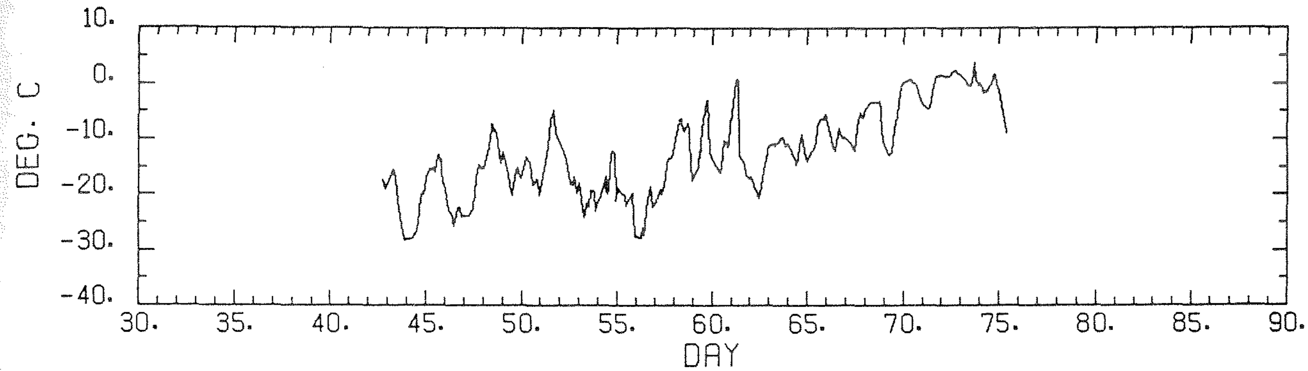


BUOY 10056 - 1992

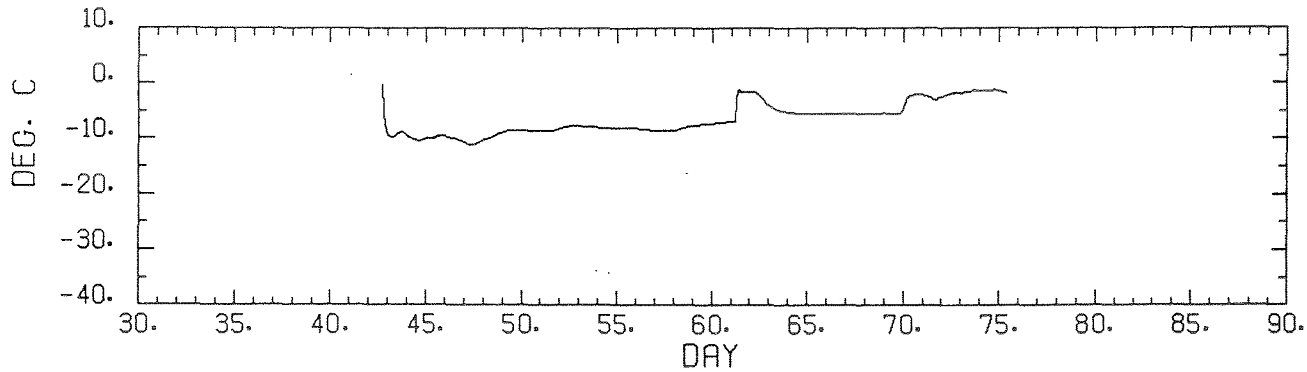
PRESSURE



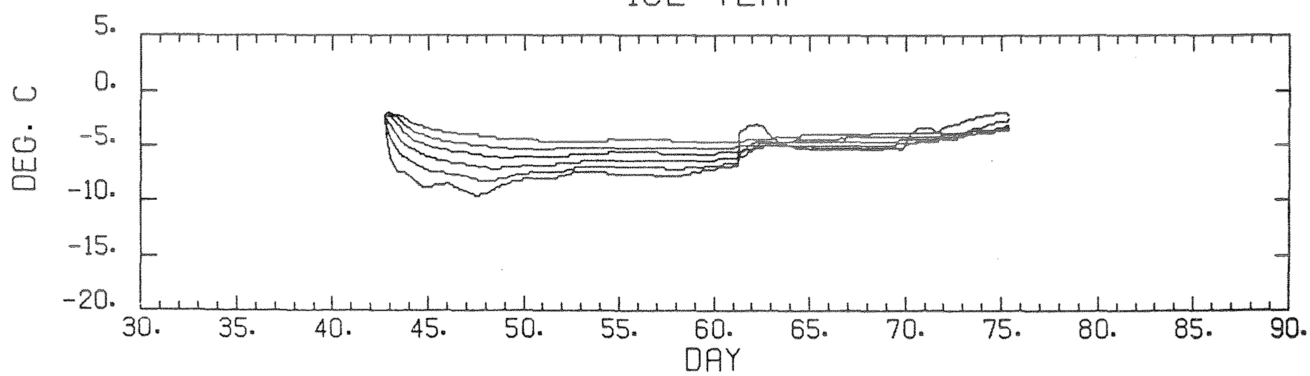
AIR TEMP

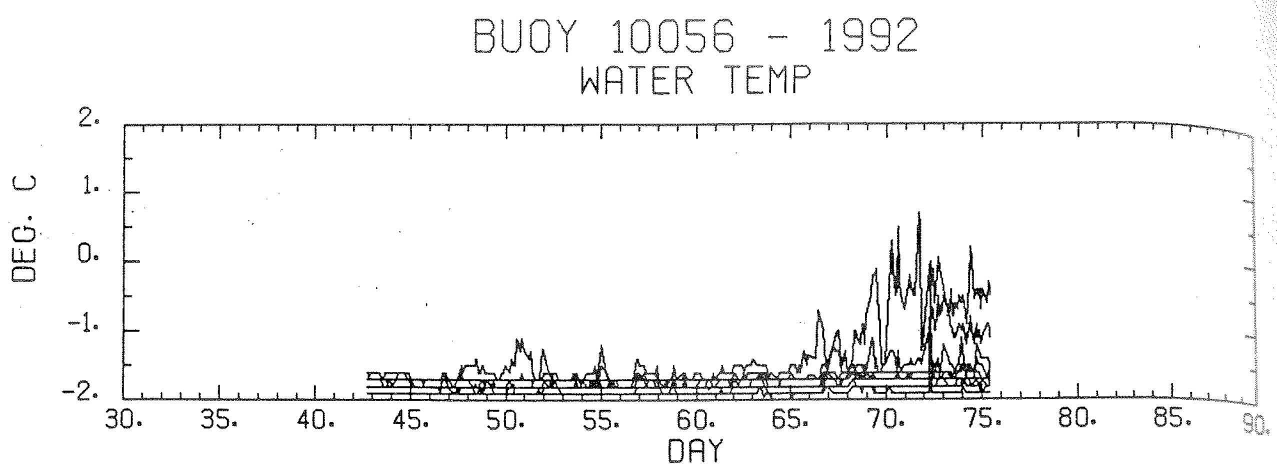


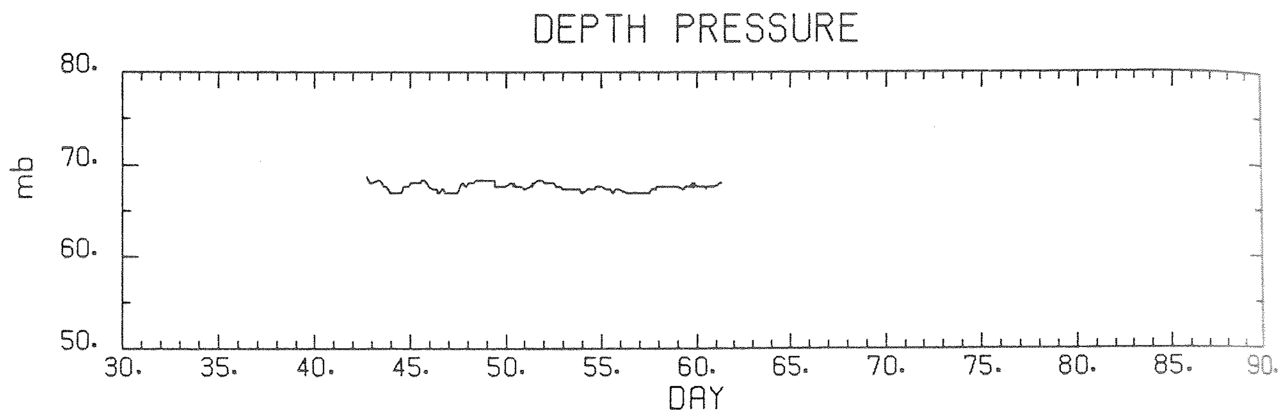
ICE TEMP (0 M)



ICE TEMP

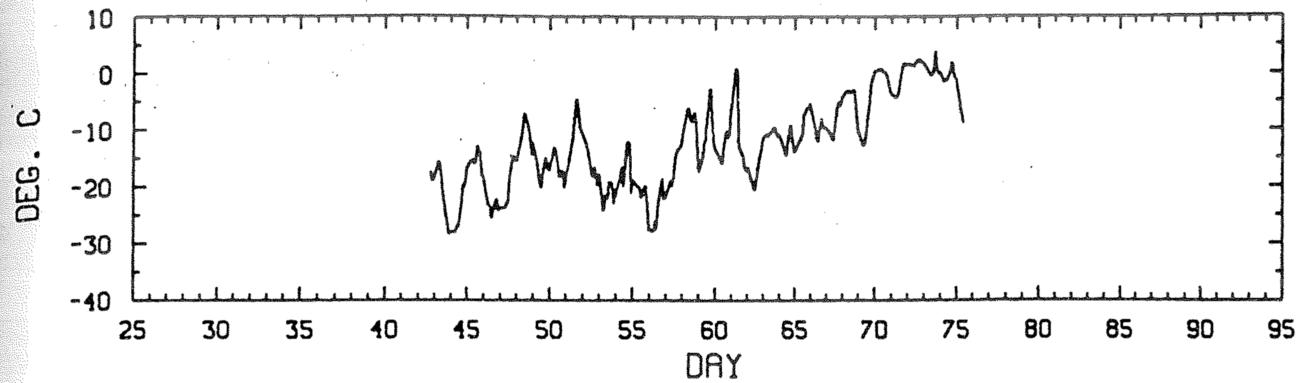



BUOY 10056 - 1992
WATER TEMP
DEG. C
2.
1.
0.
-1.
-2.
30.
35.
40.
45.
50.
55.
60.
65.
70.
75.
80.
85.
90.
DAY

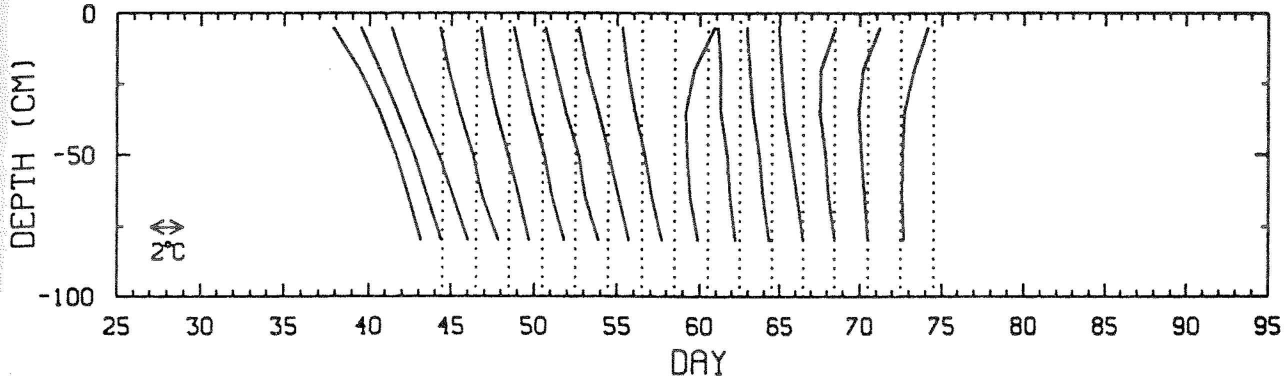

DEPTH PRESSURE
mb
80.
70.
60.
50.
30.
35.
40.
45.
50.
55.
60.
65.
70.
75.
80.
85.
90.
DAY

BUOY 10056 - 1992

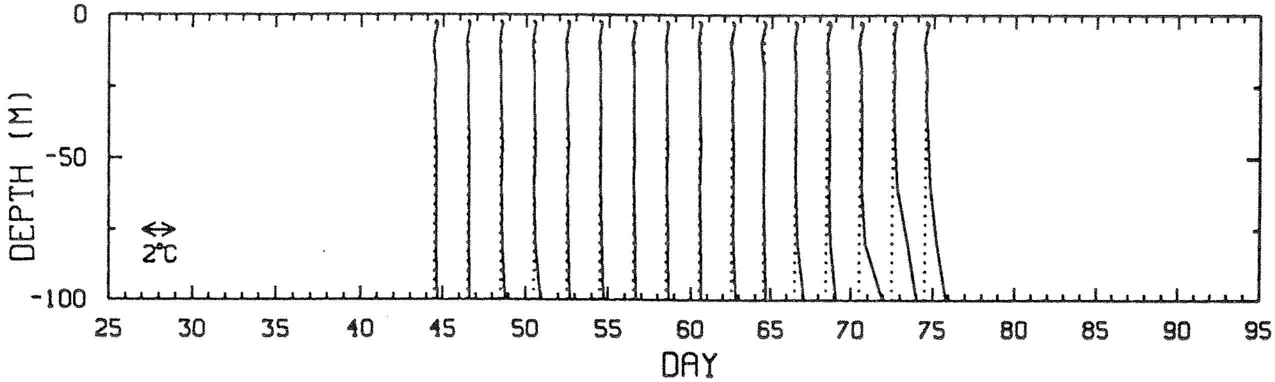
AIR TEMP



ICE TEMPERATURE (DEG. C)



WATER TEMPERATURE (DEG. C)



APPENDIX D: ICE AND SURFACE WATER SALINITY SAMPLES

Stn. 9201 Location: Sandwich Bay (2 visits)

Depth 60.0m
Lat. 53° 37.9N
Long. 57° 08.3W

1. February 11: Ice: 64cm(3) Freeboard: -10cm
Snow: 10cm hard and 8cm soft

Sample#	Depth cm	Bottle #	Salinity ppt
9201.01	10 - 15	64615	8.011
9201.02	20 - 25	64669	5.200
9201.03	35 - 40	64672	3.686

2. March 16: Ice: 78cm(4) Freeboard: -7cm
Snow: 33cm hard and 7cm soft
CTD File CART9203

Sample#	Depth cm	Bottle #	Salinity ppt
9201.06w	10 - 15	10854	13.0
9201.07w	30 - 35	10880	10.0
9201.08w	40 - 45	10848	10.0

Station 9202

Location: 60 miles east of Black Tickle
Location beacon #3320
No CTD, too cold

Lat. 54° 22.5N
Long. 55° 39.9W
(GPS loc.)

Time: February 11, 1992
Ice: Rafted, 200+cm(3)
Snow: 19cm(3) hard

Day 42, 1715GMT
Floe size 75mx75m
9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9202.01	8 - 10	64619	6.741
9202.02	35 - 40	64621	14.384
9202.03	60 - 65	64620	13.359

Station 9203

Location:	40 miles east of Black Tickle	Lat. 54° 13.0N
	Temp. Chain #10056	Long. 55° 53.0W
	CTD Stn. File PRINS100	(GPS loc.)

Time:	February 11, 1992	Day 42, 1650GMT
Ice:	Rafted, 1.6-2.0+m	Floe size 75mx75m
Snow:	21cm(3) hard	9/10 ice conc.

Station 9204

Location:	20 miles east of Black Tickle	Lat. 54° 06.5N
	Small IMP #1057	Long. 56° 02.9W
	CTD Stn. File PRINS101	(GPS loc.)

Time:	February 11, 1992	Day 42, 1850GMT
Ice:	Rafted, 2.2+m(3)	Floe size 40mx50m
Snow:	19cm (3) hard	9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9204.01	5 - 10	64622	9.170
9204.02	25 - 30	64618	9.159
9204.03	40 - 45	64617	14.413
9204.04	60 - 65	64616	19.544

Station 9205

Location:	40 miles east of Gannet Island	Lat. 54° 18.1N
	Anemometer beacon #8663	Long. 55° 44.3W
	CTD Stn. File PRINS102	(GPS Loc.)

Time:	February 12, 1991	Day 43, 1550GMT
Ice:	Rafted, 1.6m(3)	Floe size 40mx60m
Snow:	9cm(3) hard	Low visiblity

Sample#	Depth cm	Bottle #	Salinity ppt
9205.01	10 - 15	64625	6.416
9205.02	25 - 30	64627	5.917
9205.03	45 - 50	64630	7.069
9204.04	70 - 75	64629	8.107

Station 9206

Location:	30 miles east of Gannet Island	Lat. 54° 04.4N
	Temp. Chain #10054	Long. 55° 59.8W
	No CTD (too cold and windy)	(GPS Loc.)

Time:	February 12, 1992	Day 43, 1610GMT
Ice:	Rafted, 2.8+m	Floe size 40mx50m
Snow:	24cm(3) hard	9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9206.01	10 - 15	64628	5.682
9206.02	30 - 35	64662	8.644
9206.03	45 - 50	64624	8.480
9206.04	55 - 60	64626	13.000

Station 9207

Location:	20 miles east of Gannet Island	Lat. 53° 56.8N
	Location beacon #3321	Long. 56° 19.3W
	CTD Stn. File PRINS103	(GPS Loc.)

Time:	February 12, 1992	Day 43, 1730GMT
Ice:	Rafted, 2.0+m(3)	Floe size 50mx75m
Snow:	4cm(3) hard	9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9207.01	8 - 12	64668	-----
9207.02	25 - 30	64623	8.308
9207.03	45 - 50(w)	64632	17.813

Station 9208

Location:	60 miles of Black Tickle	Lat. 53° 58.8N
	Large location beacon #8647	Long. 54° 51.5W
	CTD Stn. File CART9200	(GPS Loc.)

Time:	March 16, 1992	Day 76, 1500GMT
Ice:	Rafted, 2.1+m(2)	Floe size 40mx60m
Snow:	Snow refrozen into ice	9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9208.01	10 - 15	10883	2.0
9208.02	25 - 30	10887	5.5
9208.03	50 - 55	10882	5.5
9208.04	70 - 75	10884	5.5

Station 9209

Location: 40 miles off Black Tickle — Lat. 53° 54.9N
Temp. Chain #10053 — Long. 55° 01.1W
CTD Stn. File CART9201 — GPOS Loc.)

Time: March 16, 1992 — Day 76, 1600GMT
Ice: Rafted, 2.4+m — Floe size 50mx50m
Snow: 4cm(3) of refrozen snow — 9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9209.01	5 - 10	10879	6.5
9209.02	20 - 25	10878	6.0
9209.03	35 - 40	10873	7.0
9209.04	60 - 65	10877	9.0
9209.05	75 - 80(w)	10885	13.0

Station 9210

Location: 20 miles of Black Tickle — Lat. 53° 54.8N
Atmospheric Beacon #8667 — Long. 55° 30.0W
CTD Stn. File CART9202 — (ARGOS Loc.)

Time: March 16, 1992 — Day 76, 1640GMT
Ice: Rafted, 130-165cm — Floe size 50mx50 m
Snow: 10cm of refrozen snow — 9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9210.01	10 - 15	10881	6.0
9210.02	30 - 35	10856	10.0
9210.03	40 - 45	10886	8.0
9210.04	60 - 65	10855	8.0

Station 9211

Location: 40 miles of Gannet Island — Lat. 54° 22.5N
Large location beacon #8649 — Long. 56° 00.4W
CTD Stn. File CART9204 — (GPS Loc.)

Time: March 17, 1992 — Day 77, 1330GMT
Ice: Rafted, 1.3-2.1m(3) — Floe size 50mx50m
Snow: 5cm + 3/4cm of ice — 9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9211.01	5 - 10	10880	9.0
9211.02	20 - 25	10887	10.0
9211.03	40 - 45	10882	11.0
9211.04	60 - 65	10883	27.0

Station 9212

Location:	30 miles east of Gannet Island Small IMP beacon #1052 CTD Stn. File CART9205	Lat. 54° 15.6N Long. 56° 08.0W (GPS Loc.)
Time:	March 17, 1992	Day 77, 1400GMT
Ice:	Rafted, 142cm (4)	Floe size 50mx30m
Snow:	3cm(4) of snow;3/4cm of ice	9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9212.01	5 - 10	10888	9.0
9212.02	20 - 25	10873	8.0
9212.03	30 - 35	10856	37.0
9212.04	50 - 55	10879	26.0

Station 9213

Location:	10 miles east of Gannet Island Location Beacon #4763 CTD Stn. File CART9206	Lat. 54° 11.0N Long. 56° 20.6W (GPS Loc.)
Time:	March 17, 1992	Day 77, 1515GMT
Ice:	Soft 54cm(4)	Floe size .2kmx.2km
Snow:	2cm(4) of snow; 3/4cm of ice	9/10 ice conc.

Sample#	Depth cm	Bottle #	Salinity ppt
9213.01	5 - 10	10881	12.0
9213.02	10 - 15	10848	11.0
9213.03	20 - 25	10878	12.0
9213.04	35 - 40	10885	10.0

Station 9214

Location:	Lake Melville off Long Point No beacon CTD Stn. File CART9207	Lat. 53° 40.0N Long. 59° 30.0W (Map Loc.)
Time:	March 17, 1992	Day 77, 1745GMT
Ice:	162cm of hard ice	Lake ice
Snow:	10cm of hard snow	

Sample#	Depth cm	Bottle #	Salinity ppt
9214.01	5 - 10	10886	3.0
9214.02	30 - 35	10855	3.0
9214.03	50 - 55	10864	3.0
9214.04	70 - 75	10871	3.0
9214.05	Water	10877	3.0

APPENDIX E: TEMPERATURE AND SALINITY DATA

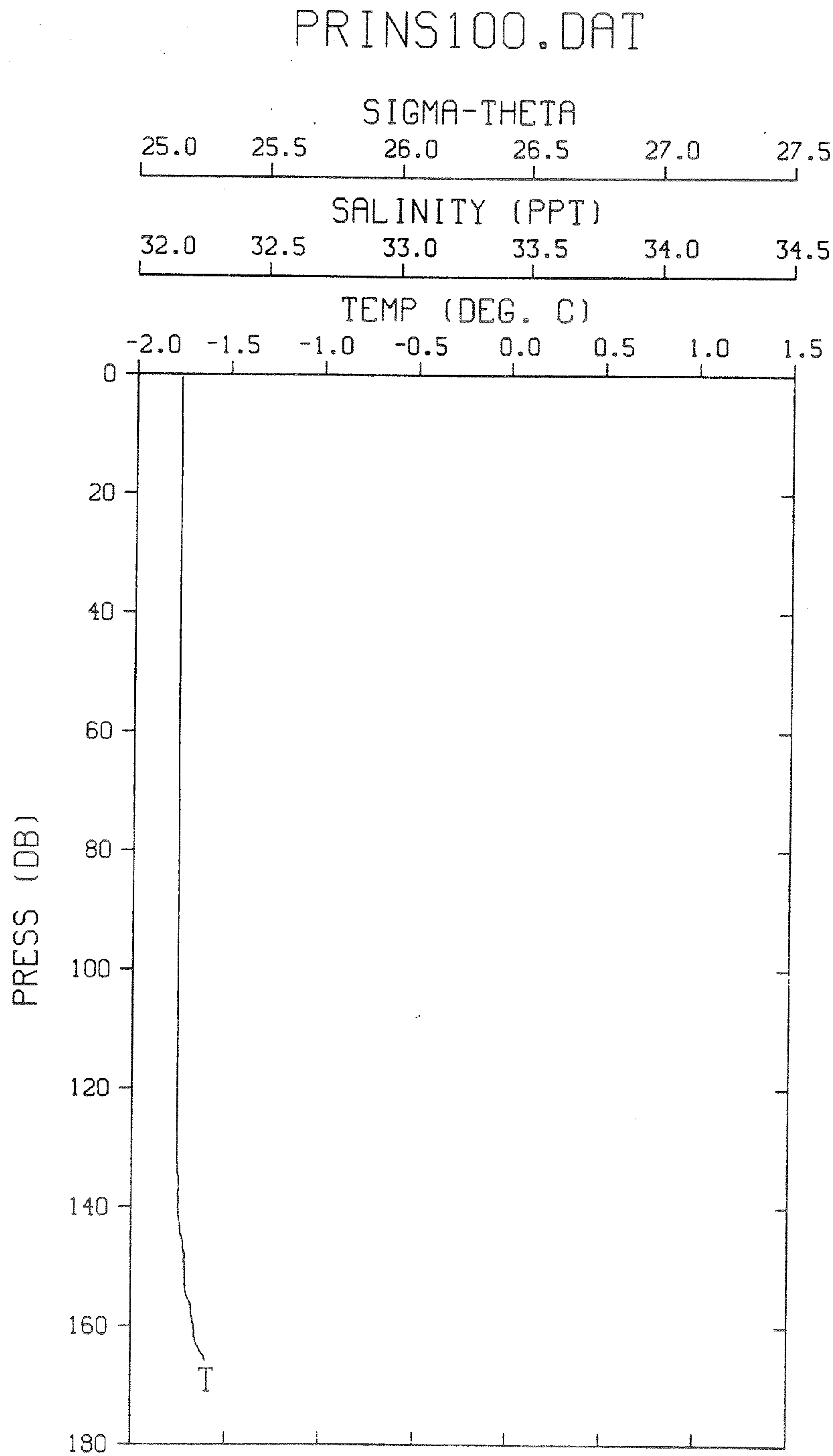
Plots and listings of Seabird CTD data (pressure, temperature, salinity and density (σ_θ)). In the plots, T_f represents the freezing point at in situ pressure.

	Stn. #	Date	Site	Beacon #	File #
1.	9203	Feb. 11	middle	10056	PRINS100
2.	9204	Feb. 11	inner	1057	PRINS101
3.	9205	Feb. 12	outer	8663	PRINS102
4.	9207	Feb. 12	inner	3321	PRINS103
5.	9208	Mar. 16	outer	8647	CART9200
6.	9209	Mar. 16	middle	10053	CART9201
7.	9210	Mar. 16	inner	8667	CART9202
8.	9201	Mar. 16	landfast	10057	CART9203
9.	9211	Mar. 17	outer	8649	CART9204
10.	9212	Mar. 17	middle	1052	CART9205
11.	9213	Mar. 17	inner	4763	CART9206
12.	9214	Mar. 17	Lake	Melville	CART9207

Station #9203 on February 11, 1992

Raw data file: prins100.dat

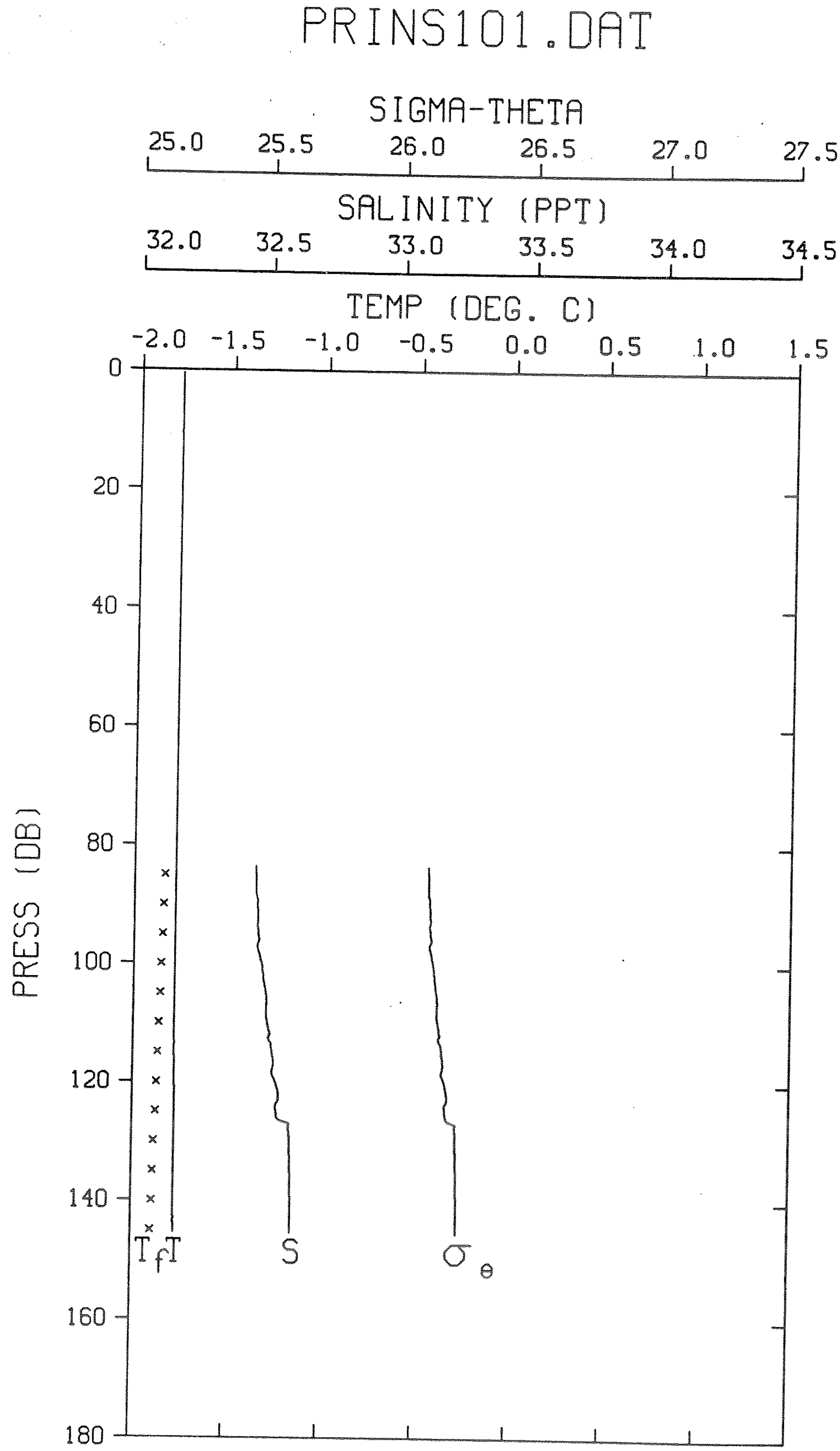
decibars	temp
5.	-1.7669
10.	-1.7655
15.	-1.7653
20.	-1.7656
25.	-1.7655
30.	-1.7650
35.	-1.7643
40.	-1.7643
45.	-1.7643
50.	-1.7642
55.	-1.7642
60.	-1.7641
65.	-1.7641
70.	-1.7628
75.	-1.7629
80.	-1.7609
85.	-1.7607
90.	-1.7613
95.	-1.7606
100.	-1.7612
105.	-1.7616
110.	-1.7615
115.	-1.7620
120.	-1.7624
125.	-1.7619
130.	-1.7607
135.	-1.7515
140.	-1.7554
145.	-1.7351
150.	-1.7179
155.	-1.7064
160.	-1.6692
165.	-1.6130


PRINS100.DAT
SIGMA-THETA
25.0 25.5 26.0 26.5 27.0 27.5
SALINITY (PPT)
32.0 32.5 33.0 33.5 34.0 34.5
TEMP (DEG. C)
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5
PRESS (DB)
0 20 40 60 80 100 120 140 160 180
T

Station #9204 on February 11, 1992

Raw data file:prins101.dat

decibars	temp	salinity	sigmatheta
5.	-1.7802		
10.	-1.7802		
15.	-1.7801		
25.	-1.7798		
30.	-1.7802		
35.	-1.7802		
40.	-1.7800		
45.	-1.7800		
50.	-1.7805		
55.	-1.7803		
60.	-1.7802		
65.	-1.7804		
70.	-1.7802		
75.	-1.7800		
80.	-1.7801		
85.	-1.7797	32.4645	26.1191
90.	-1.7796	32.4723	26.1254
95.	-1.7789	32.4759	26.1283
100.	-1.7792	32.4895	26.1394
105.	-1.7781	32.5073	26.1538
110.	-1.7779	32.5138	26.1591
115.	-1.7774	32.5321	26.1740
120.	-1.7755	32.5467	26.1858
125.	-1.7745	32.5516	26.1897
130.	-1.7724	32.6021	26.2307
135.	-1.7745	32.6060	26.2340
140.	-1.7729	32.6087	26.2362
145.	-1.7719	32.6102	26.2374

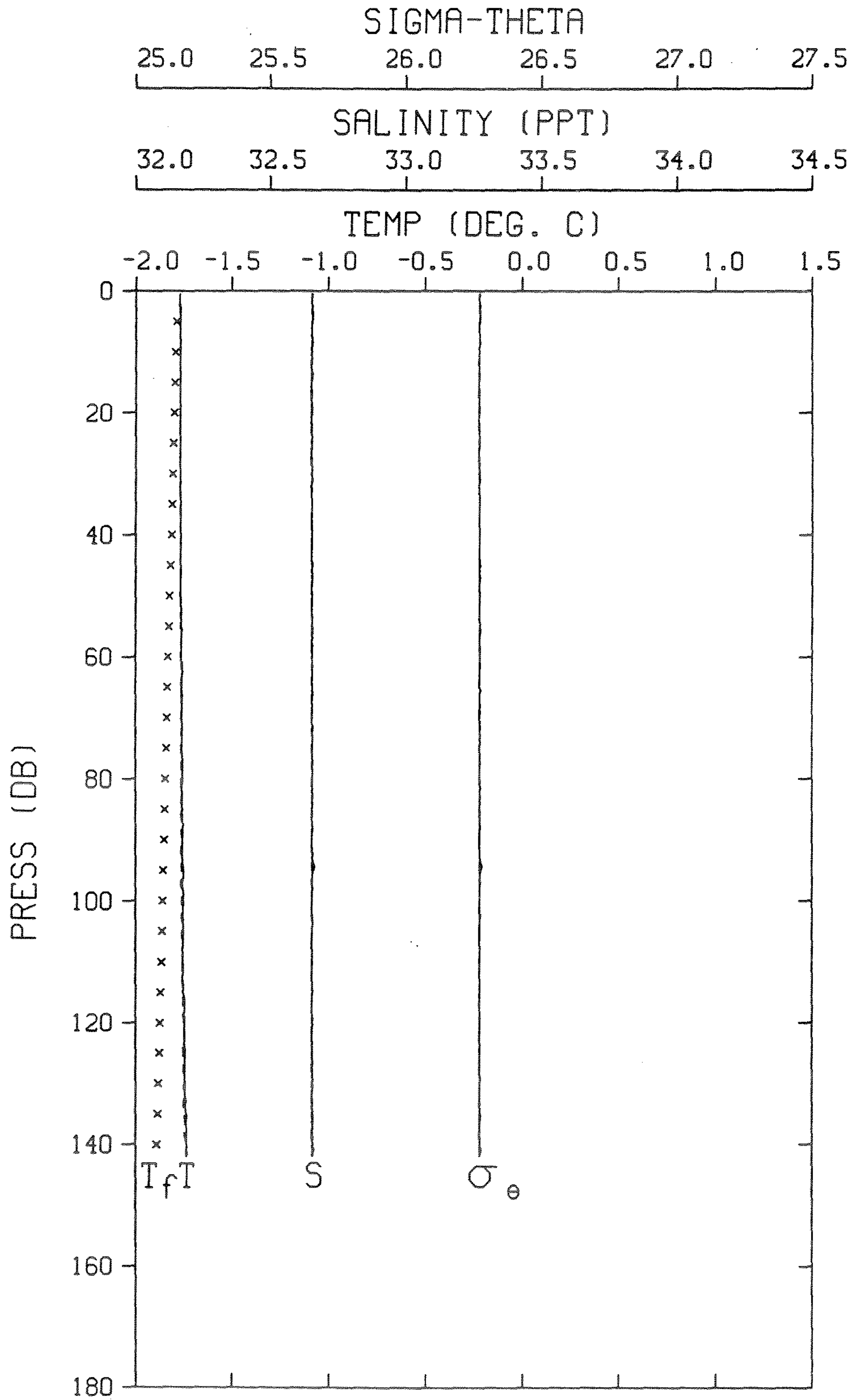

PRINS101.DAT
SIGMA-THETA
25.0
25.5
26.0
26.5
27.0
27.5
SALINITY (PPT)
32.0
32.5
33.0
33.5
34.0
34.5
TEMP (DEG. C)
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
PRESS (DB)
0
20
40
60
80
100
120
140
160
180
T
f
T
S
σ θ

Station #9205 on February 12, 1992

Raw data file: prins102.dat

decibars	temp	salinity	sigmatheta
5.	-1.7685	32.6543	26.2730
10.	-1.7675	32.6542	26.2730
15.	-1.7665	32.6544	26.2731
20.	-1.7673	32.6542	26.2729
25.	-1.7668	32.6542	26.2729
30.	-1.7663	32.6543	26.2730
35.	-1.7650	32.6542	26.2729
40.	-1.7643	32.6545	26.2731
45.	-1.7647	32.6540	26.2727
50.	-1.7634	32.6545	26.2731
55.	-1.7625	32.6544	26.2730
60.	-1.7624	32.6545	26.2731
65.	-1.7621	32.6543	26.2730
70.	-1.7610	32.6544	26.2730
75.	-1.7614	32.6546	26.2732
80.	-1.7620	32.6543	26.2730
85.	-1.7612	32.6546	26.2731
90.	-1.7590	32.6540	26.2727
95.	-1.7596	32.6540	26.2727
100.	-1.7595	32.6542	26.2728
105.	-1.7579	32.6541	26.2727
110.	-1.7572	32.6555	26.2739
115.	-1.7533	32.6545	26.2730
120.	-1.7493	32.6546	26.2730
125.	-1.7519	32.6542	26.2727
130.	-1.7480	32.6538	26.2723
135.	-1.7483	32.6556	26.2738
140.	-1.7369	32.6577	26.2752

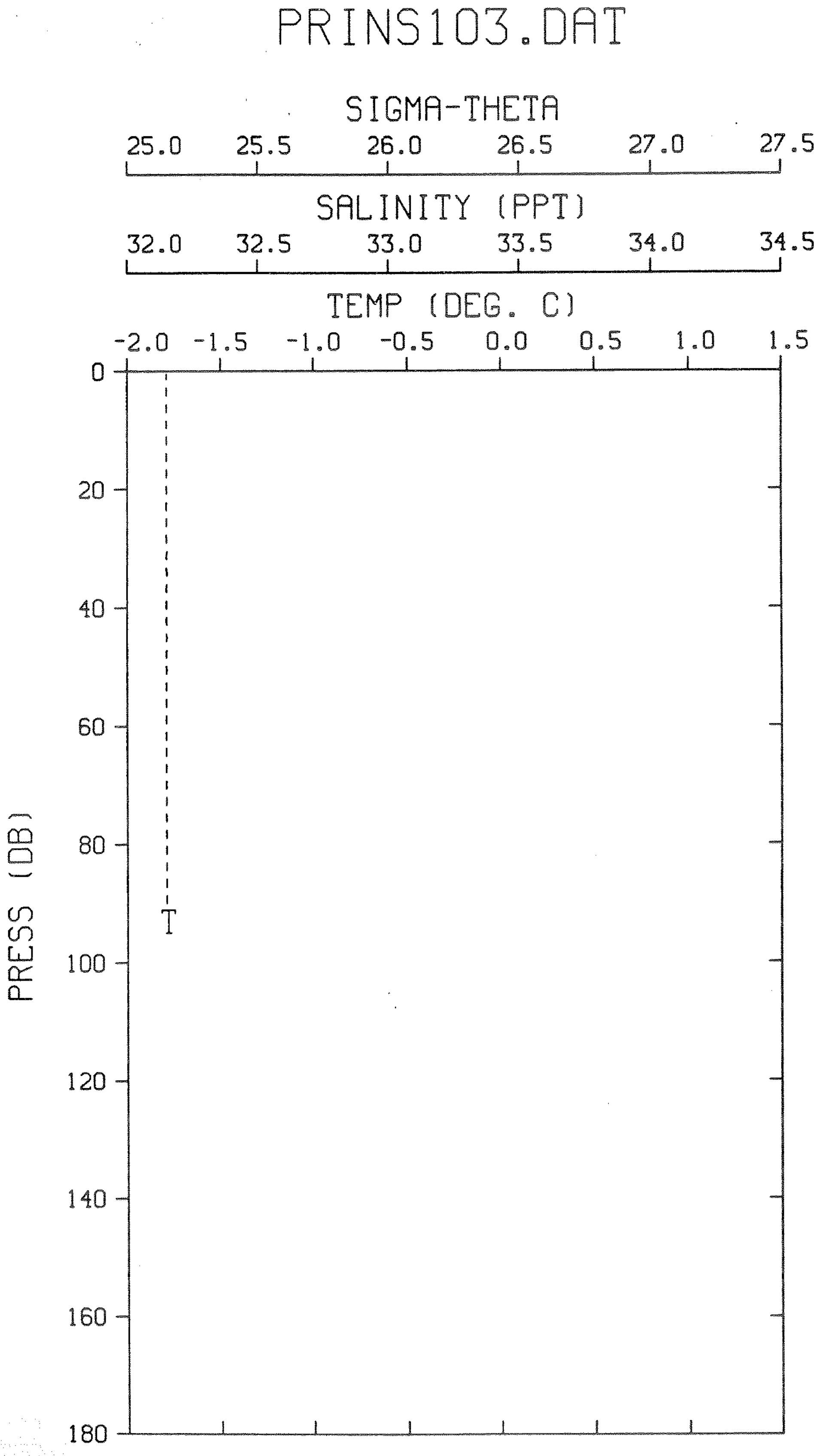
PRINS102.DAT



Station #9207 on February 12, 1992

Raw data file: prinsl03.dat

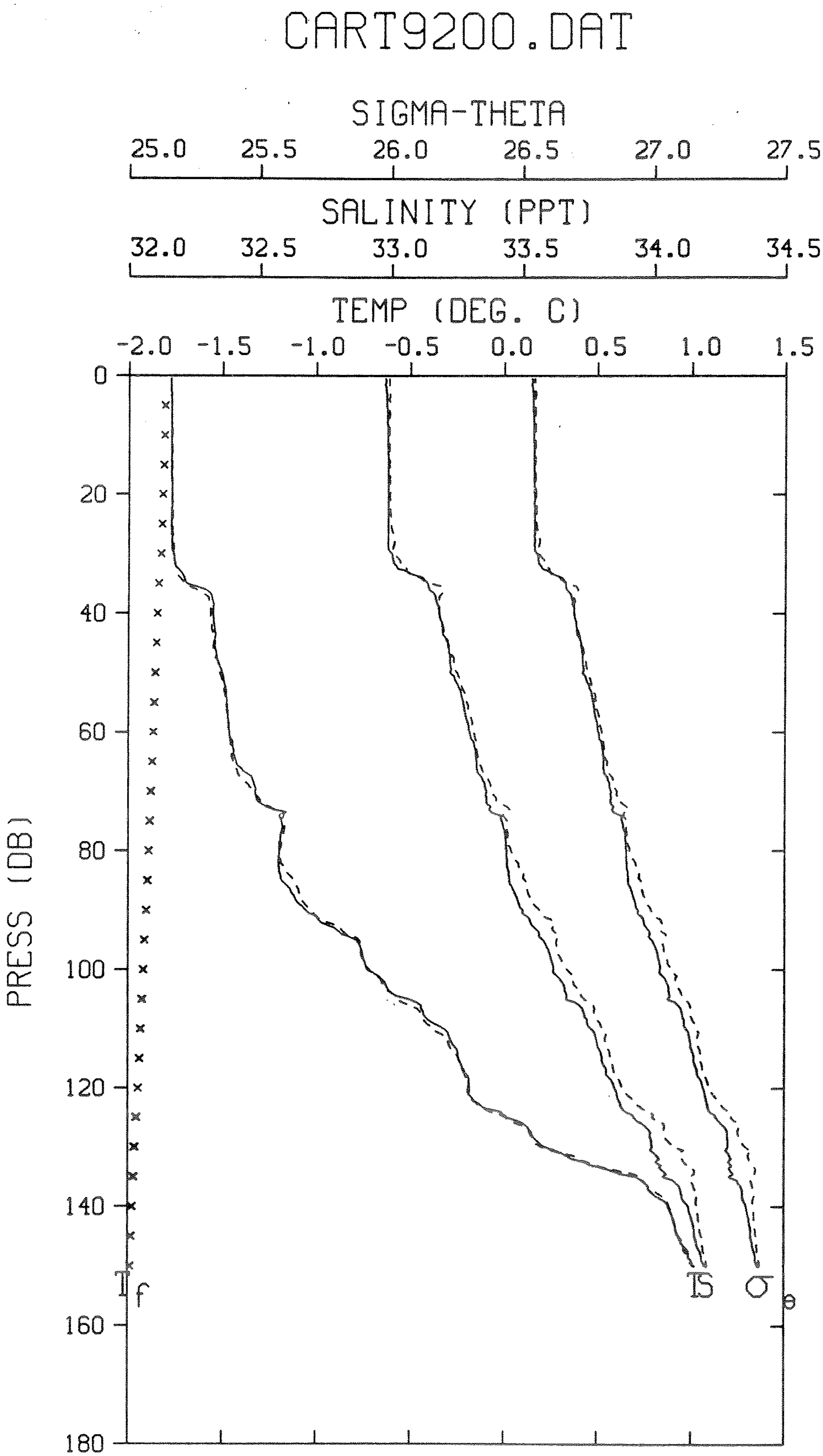
decibars	temp
5.	-1.7907
10.	-1.7906
15.	-1.7908
20.	-1.7899
25.	-1.7903
30.	-1.7898
35.	-1.7898
40.	-1.7897
45.	-1.7896
50.	-1.7898
55.	-1.7899
60.	-1.7902
65.	-1.7905
70.	-1.7906
75.	-1.7904
80.	-1.7902
85.	-1.7902
90.	-1.7909


PRINS103.DAT
SIGMA-THETA
25.0 25.5 26.0 26.5 27.0 27.5
SALINITY (PPT)
32.0 32.5 33.0 33.5 34.0 34.5
TEMP (DEG. C)
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5
PRESS (DB)
0 20 40 60 80 100 120 140 160 180
T

Station #9208 on March 16, 1992

Raw data file: cart9200.dat

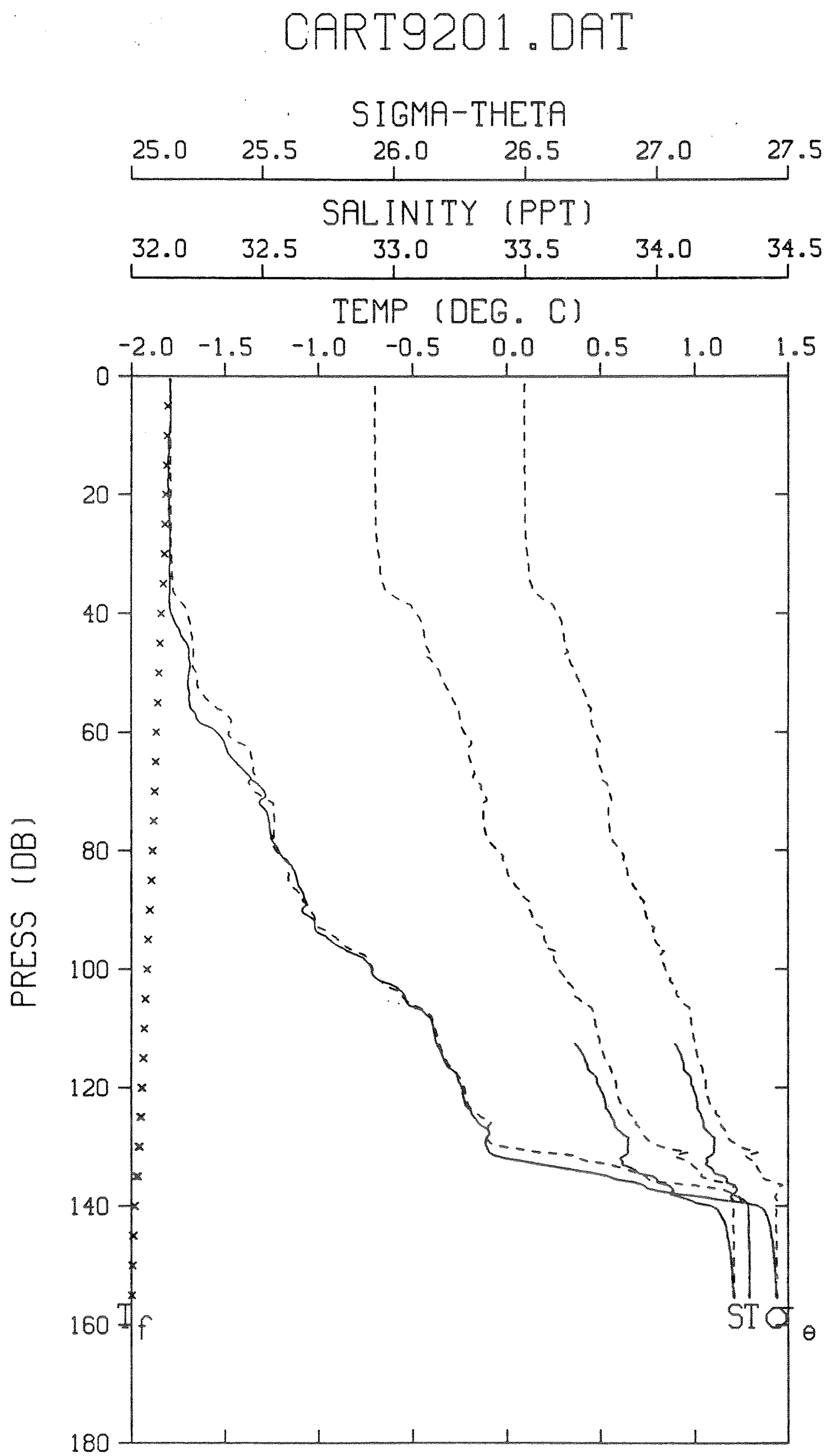
decibars	temp	salinity	sigmatheta
5.	-1.7741	32.9911	26.5470
10.	-1.7712	32.9899	26.5459
15.	-1.7711	32.9906	26.5465
20.	-1.7690	32.9934	26.5487
25.	-1.7681	32.9967	26.5514
30.	-1.7654	33.0077	26.5602
35.	-1.7025	33.1541	26.6778
40.	-1.5652	33.1806	26.6959
45.	-1.5465	33.2139	26.7224
50.	-1.5158	33.2483	26.7495
55.	-1.4833	33.2863	26.7796
60.	-1.4625	33.3135	26.8011
65.	-1.4424	33.3400	26.8220
70.	-1.3322	33.3903	26.8596
75.	-1.1769	33.4430	26.8975
80.	-1.1926	33.4563	26.9088
85.	-1.1229	33.5109	26.9508
90.	-1.0265	33.5646	26.9910
95.	-0.7705	33.6319	27.0361
100.	-0.7166	33.6741	27.0681
105.	-0.5662	33.7401	27.1154
110.	-0.3702	33.8084	27.1621
115.	-0.2377	33.8383	27.1802
120.	-0.1792	33.8827	27.2133
125.	0.0152	33.9973	27.2962
130.	0.2053	34.0802	27.3532
135.	0.7373	34.1401	27.3709
140.	0.8833	34.1685	27.3847
145.	0.9339	34.1855	27.3951
150.	1.0226	34.2064	27.4063


CART9200.DAT
SIGMA-THETA
25.0 25.5 26.0 26.5 27.0 27.5
SALINITY (PPT)
32.0 32.5 33.0 33.5 34.0 34.5
TEMP (DEG. C)
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5
PRESS (DB)
0 20 40 60 80 100 120 140 160 180
Tf
T S
σθ

Station #9209 on March 16, 1992

Raw data file: cart9201.dat

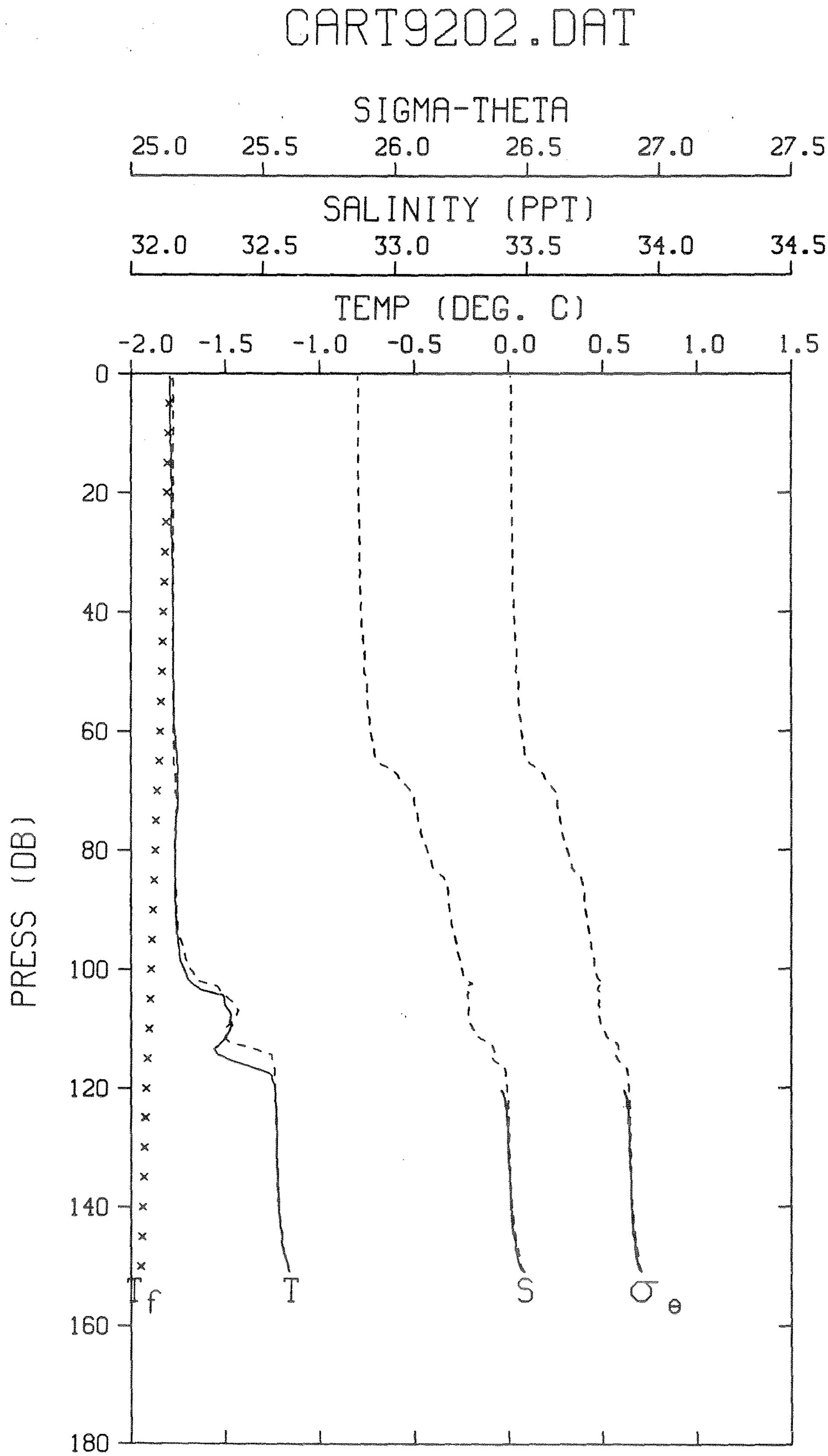
decibars	temp	salinity	sigmatheta
5.	-1.7904	32.9290	26.4968
10.	-1.7901	32.9280	26.4960
15.	-1.7901	32.9298	26.4975
20.	-1.7895	32.9306	26.4981
25.	-1.7894	32.9322	26.4994
30.	-1.7860	32.9424	26.5077
35.	-1.7788	32.9585	26.5206
40.	-1.7001	33.0862	26.6226
45.	-1.6727	33.1226	26.6515
50.	-1.6528	33.1769	26.6951
55.	-1.5786	33.2326	26.7385
60.	-1.4800	33.2684	26.7649
65.	-1.3496	33.2940	26.7820
70.	-1.3411	33.3414	26.8202
75.	-1.2356	33.3431	26.8183
80.	-1.2281	33.4005	26.8647
85.	-1.1599	33.4450	26.8985
90.	-1.0463	33.5170	26.9531
95.	-0.8947	33.5719	26.9922
100.	-0.7103	33.6272	27.0299
105.	-0.5424	33.7063	27.0870
110.	-0.3787	33.7711	27.1323
115.	-0.3249	33.8013	27.1543
120.	-0.2243	33.8452	27.1851
125.	-0.1350	33.9159	27.2379
130.	-0.0250	34.0140	27.3118
135.	0.7387	34.1650	27.3909
140.	1.2833	34.2893	27.4555
145.	1.2913	34.2921	27.4572
150.	1.2921	34.2922	27.4572
155.	1.2900	34.2932	27.4582


CART9201.DAT
SIGMA-THETA
25.0 25.5 26.0 26.5 27.0 27.5
SALINITY (PPT)
32.0 32.5 33.0 33.5 34.0 34.5
TEMP (DEG. C)
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5
PRESS (DB)
0 20 40 60 80 100 120 140 160 180
T_f
S T σ_θ

Station #9210 on March 16, 1992

Raw data file: cart9202.dat

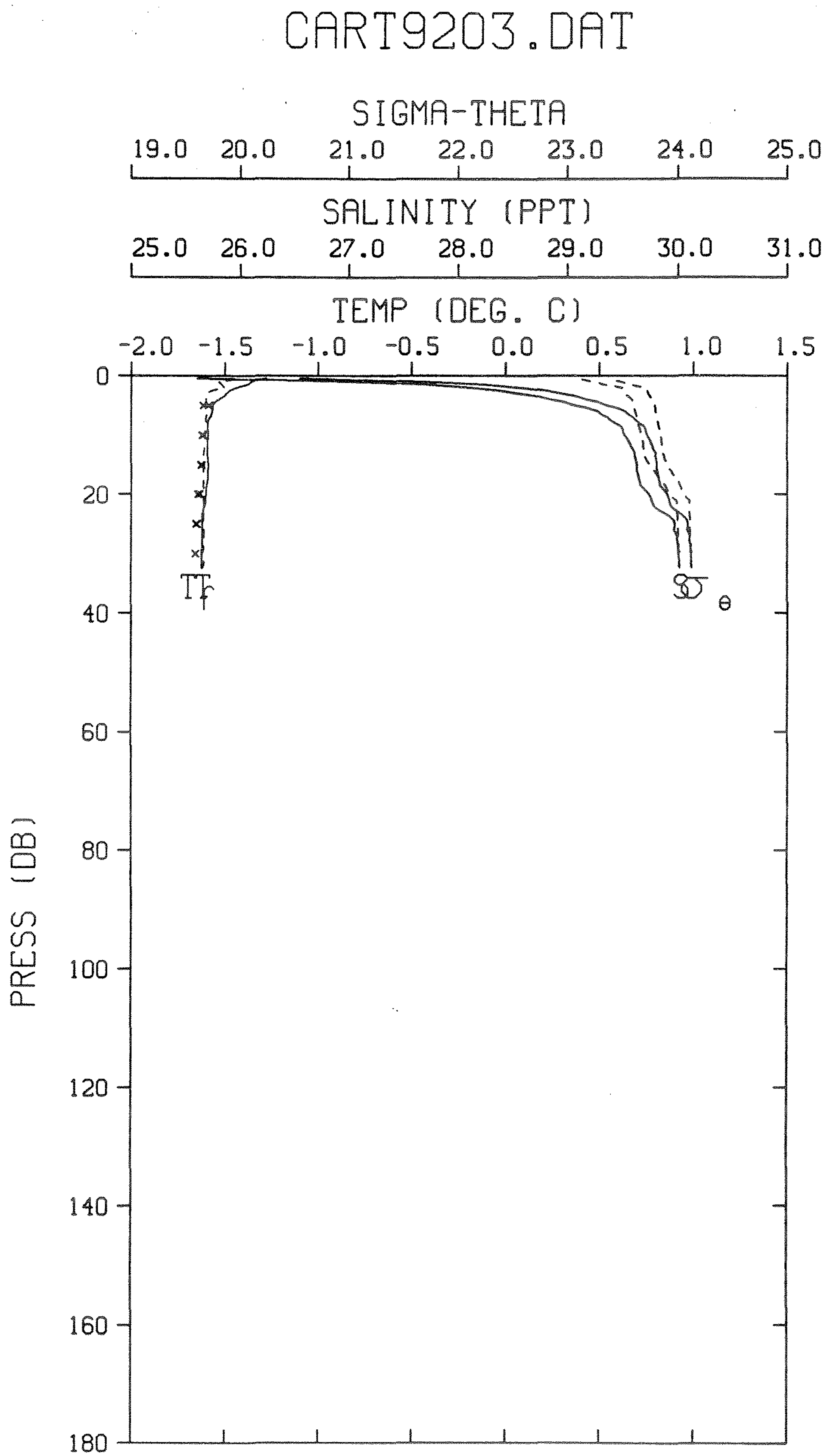
decibars	temp	salinity	sigmatheta
5.	-1.7766	32.8605	26.4409
10.	-1.7764	32.8608	26.4411
15.	-1.7763	32.8607	26.4410
20.	-1.7763	32.8619	26.4420
25.	-1.7764	32.8653	26.4447
30.	-1.7762	32.8669	26.4461
35.	-1.7760	32.8676	26.4466
40.	-1.7761	32.8717	26.4500
45.	-1.7764	32.8807	26.4573
50.	-1.7764	32.8828	26.4590
55.	-1.7764	32.8937	26.4679
60.	-1.7756	32.9058	26.4777
65.	-1.7735	32.9319	26.4989
70.	-1.7646	33.0570	26.6003
75.	-1.7608	33.0857	26.6236
80.	-1.7681	33.1191	26.6509
85.	-1.7666	33.1874	26.7064
90.	-1.7616	33.2045	26.7202
95.	-1.7395	33.2289	26.7395
100.	-1.6877	33.2527	26.7576
105.	-1.4851	33.2768	26.7719
110.	-1.4988	33.2930	26.7855
115.	-1.2519	33.3678	26.8389
120.	-1.2330	33.4250	26.8847
125.	-1.2274	33.4323	26.8905
130.	-1.2269	33.4328	26.8909
135.	-1.2235	33.4348	26.8924
140.	-1.2175	33.4424	26.8983
145.	-1.1962	33.4564	26.9091
150.	-1.1663	33.4769	26.9247


CART9202.DAT
SIGMA-THETA
25.0
25.5
26.0
26.5
27.0
27.5
SALINITY (PPT)
32.0
32.5
33.0
33.5
34.0
34.5
TEMP (DEG. C)
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
PRESS (DB)
0
20
40
60
80
100
120
140
160
180
T_f
T
S
σ_θ

Station #9201 on March 16, 1992

Raw data file: cart9203.dat

decibars	temp	salinity	sigmatheta
5.	-1.5989	29.6018	23.7906
10.	-1.6065	29.6682	23.8446
15.	-1.6135	29.7456	23.9075
20.	-1.6161	29.9286	24.0561
25.	-1.6131	29.9980	24.1124
30.	-1.6218	30.0176	24.1285

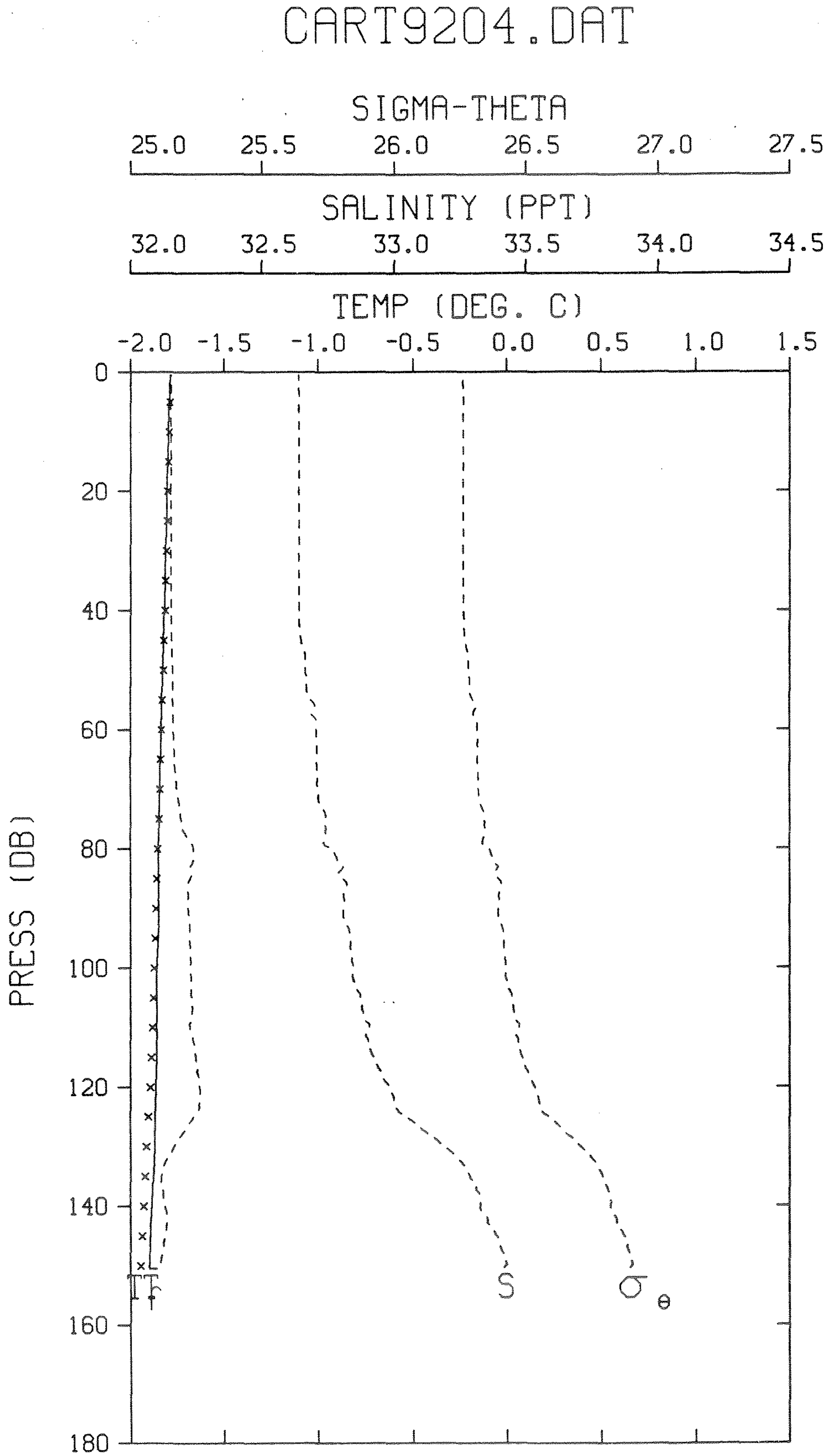


CART9203.DAT
SIGMA-THETA
19.0 20.0 21.0 22.0 23.0 24.0 25.0
SALINITY (PPT)
25.0 26.0 27.0 28.0 29.0 30.0 31.0
TEMP (DEG. C)
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5
PRESS (DB)
0 20 40 60 80 100 120 140 160 180

Station #9211 on March 17, 1992

Raw data file: cart9204.dat

decibars	temp	salinity	sigmatheta
5.	-1.7831	32.6428	26.2640
10.	-1.7826	32.6426	26.2638
15.	-1.7827	32.6424	26.2637
20.	-1.7827	32.6428	26.2640
25.	-1.7827	32.6431	26.2643
30.	-1.7822	32.6429	26.2641
35.	-1.7820	32.6433	26.2644
40.	-1.7805	32.6433	26.2644
45.	-1.7773	32.6503	26.2700
50.	-1.7744	32.6669	26.2835
55.	-1.7724	32.6862	26.2991
60.	-1.7692	32.7073	26.3162
65.	-1.7618	32.7095	26.3178
70.	-1.7484	32.7138	26.3210
75.	-1.7297	32.7428	26.3441
80.	-1.6626	32.7695	26.3643
85.	-1.6794	32.8089	26.3968
90.	-1.6904	32.8109	26.3986
95.	-1.6809	32.8344	26.4175
100.	-1.6774	32.8445	26.4257
105.	-1.6712	32.8719	26.4477
110.	-1.6835	32.9068	26.4764
115.	-1.6503	32.9218	26.4878
120.	-1.6331	32.9785	26.5334
125.	-1.6585	33.0410	26.5849
130.	-1.7642	33.1859	26.7051
135.	-1.8337	33.2862	26.7883
140.	-1.8155	33.3299	26.8234
145.	-1.8126	33.3888	26.8713
150.	-1.8424	33.4317	26.9069

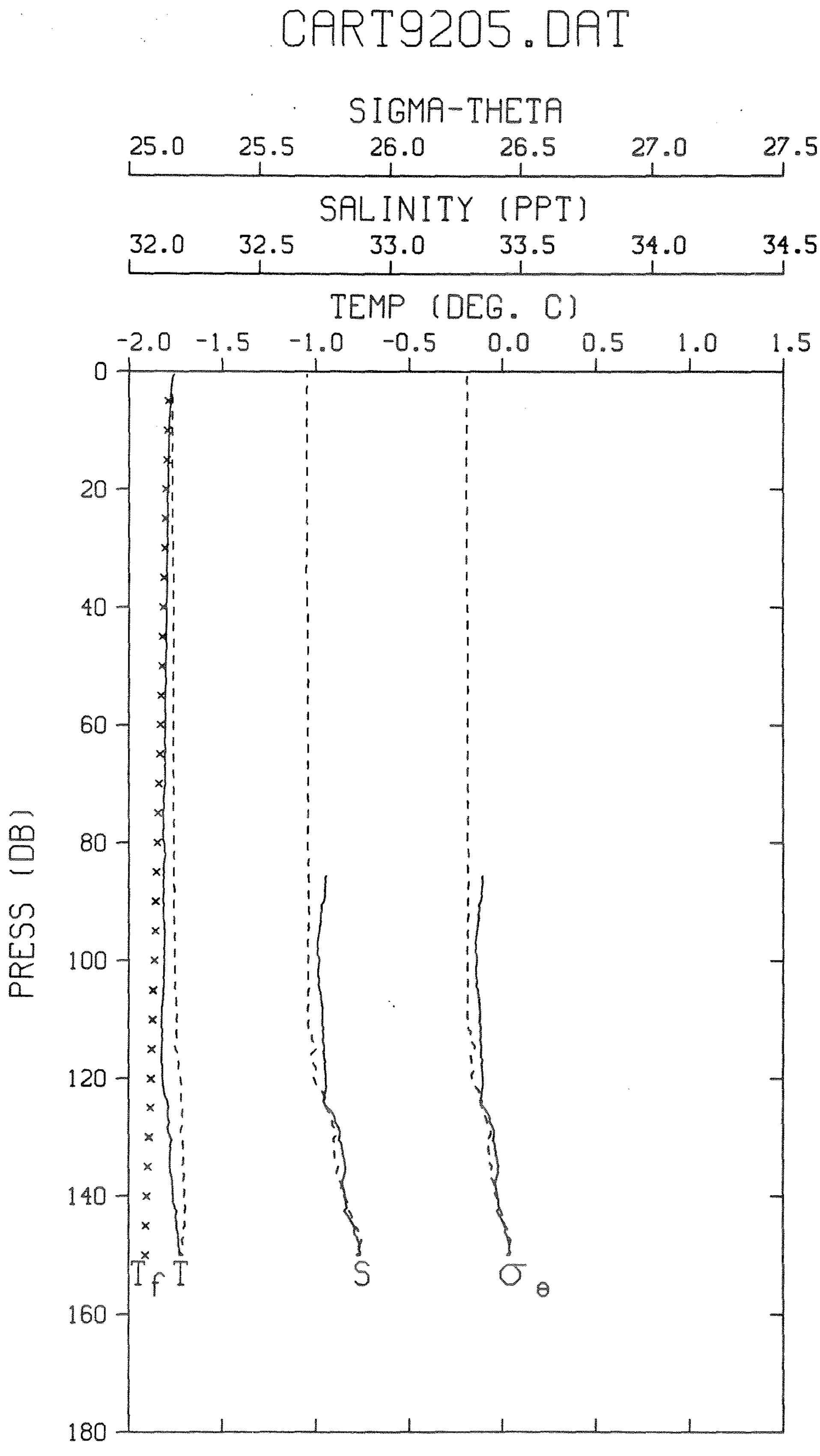


CART9204.DAT
SIGMA-THETA
25.0
25.5
26.0
26.5
27.0
27.5
SALINITY (PPT)
32.0
32.5
33.0
33.5
34.0
34.5
TEMP (DEG. C)
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
PRESS (DB)
0
20
40
60
80
100
120
140
160
180
T
T
S
σθ

Staation #9212 on March 17, 1992

Raw data file: cart9205.dat

decibars	temp	salinity	sigmatheta
5.	-1.7681	32.6813	26.2950
10.	-1.7676	32.6802	26.2941
15.	-1.7674	32.6806	26.2944
20.	-1.7667	32.6803	26.2941
25.	-1.7665	32.6810	26.2948
30.	-1.7654	32.6805	26.2943
35.	-1.7628	32.6796	26.2935
40.	-1.7615	32.6827	26.2960
45.	-1.7615	32.6846	26.2976
50.	-1.7615	32.6856	26.2983
55.	-1.7608	32.6851	26.2980
60.	-1.7604	32.6850	26.2979
65.	-1.7600	32.6852	26.2980
70.	-1.7597	32.6858	26.2985
75.	-1.7593	32.6862	26.2988
80.	-1.7585	32.6859	26.2986
85.	-1.7596	32.6882	26.3005
90.	-1.7587	32.6888	26.3010
95.	-1.7547	32.6857	26.2983
100.	-1.7526	32.6859	26.2984
105.	-1.7497	32.6866	26.2989
110.	-1.7421	32.6884	26.3003
115.	-1.7506	32.7188	26.3251
120.	-1.7213	32.7072	26.3151
125.	-1.7114	32.7541	26.3529
130.	-1.7155	32.7873	26.3801
135.	-1.7137	32.7996	26.3900
140.	-1.7034	32.8235	26.4092
145.	-1.6972	32.8610	26.4395
150.	-1.7085	32.8711	26.4480

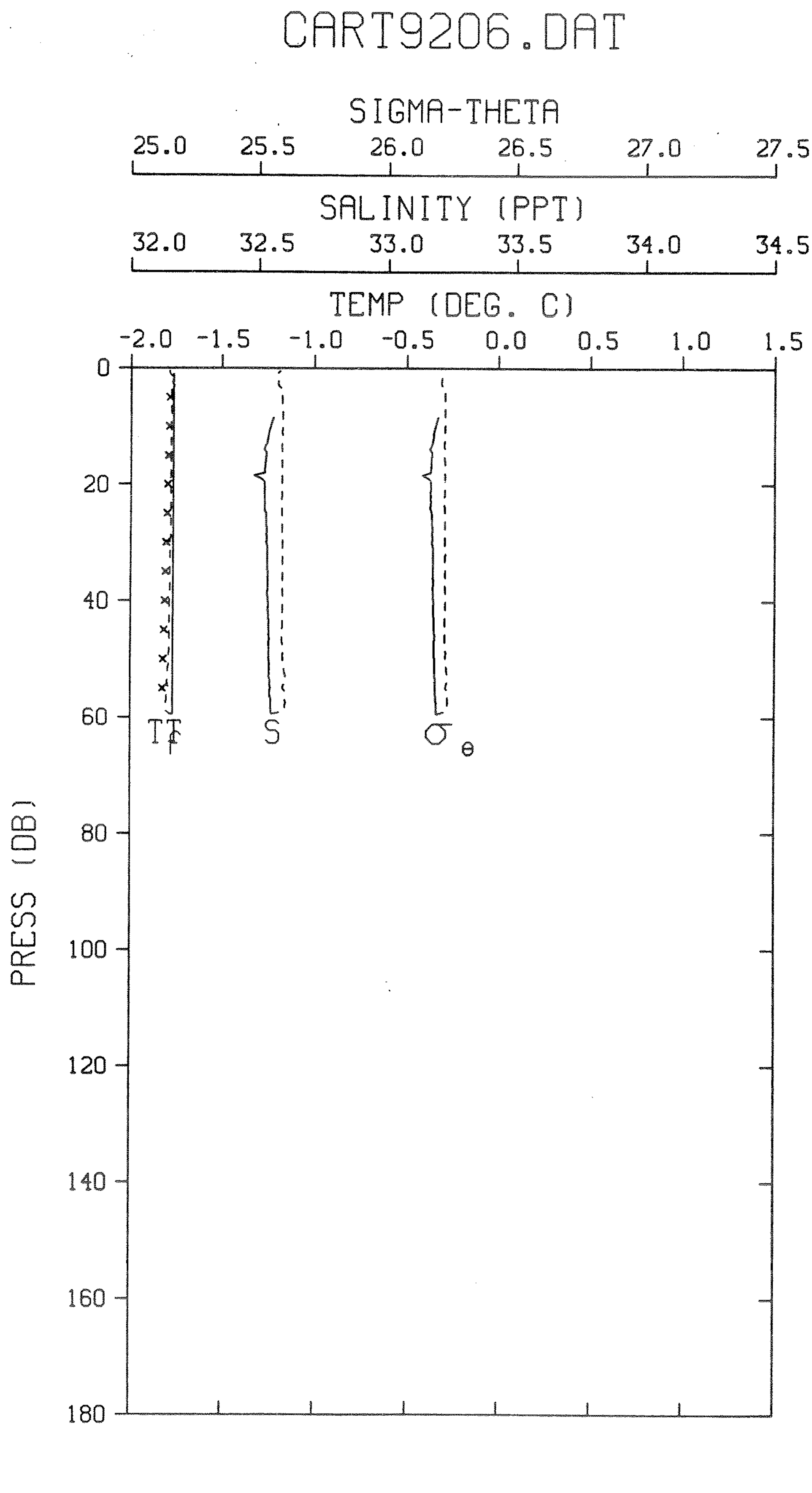


CART9205.DAT
SIGMA-THETA
25.0 25.5 26.0 26.5 27.0 27.5
SALINITY (PPT)
32.0 32.5 33.0 33.5 34.0 34.5
TEMP (DEG. C)
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5
PRESS (DB)
0 20 40 60 80 100 120 140 160 180
T_f T
S
σ_θ

Station #9213 on March 17, 1992

Raw data file: cart9206.dat

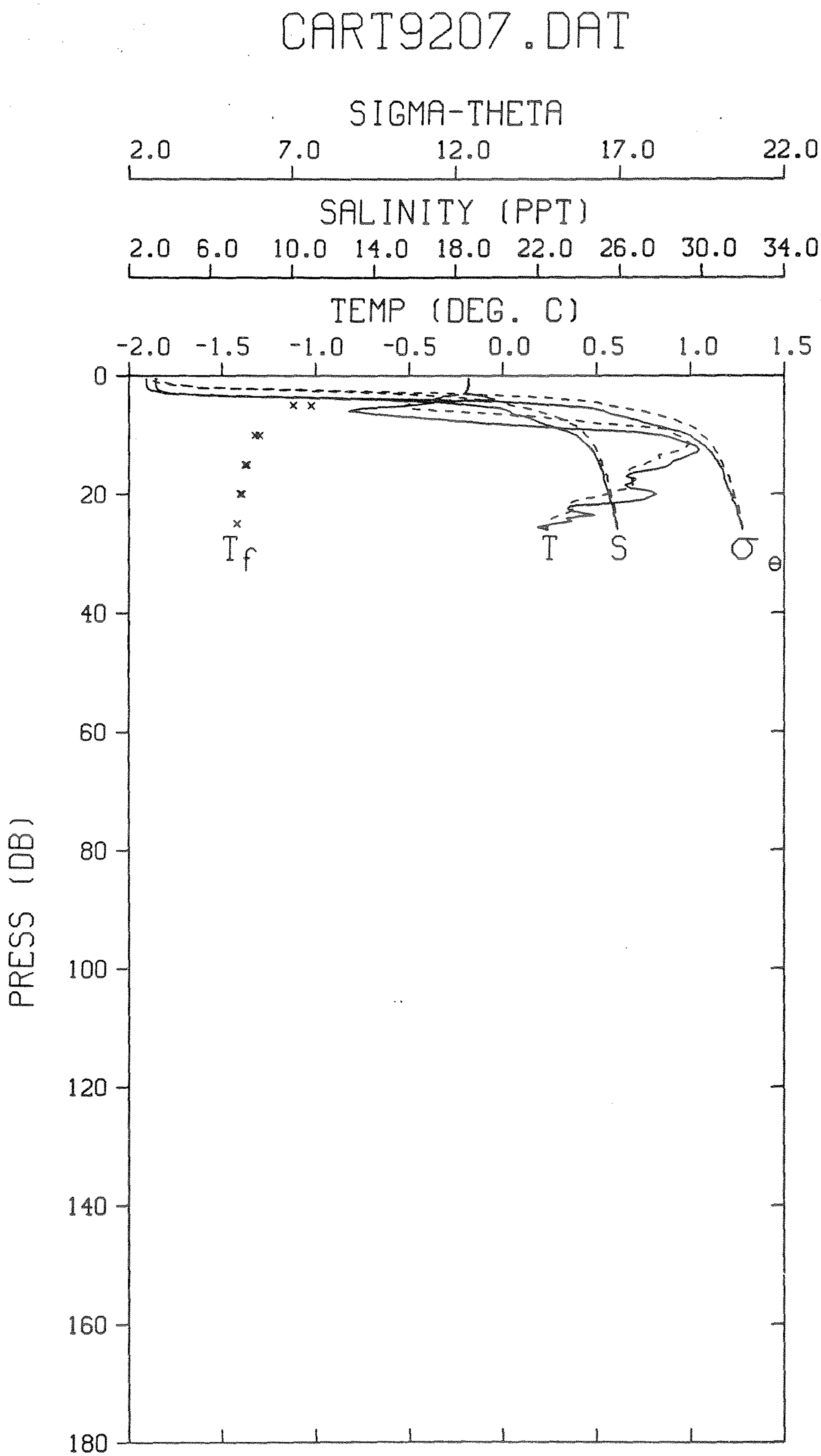
decibars	temp	salinity	sigmatheta
5.	-1.7751	32.5888	26.2200
10.	-1.7783	32.5901	26.2211
15.	-1.7774	32.5871	26.2187
20.	-1.7784	32.5890	26.2202
25.	-1.7796	32.5889	26.2202
30.	-1.7808	32.5897	26.2208
35.	-1.7819	32.5906	26.2216
40.	-1.7842	32.5919	26.2227
45.	-1.7836	32.5888	26.2201
50.	-1.7877	32.5924	26.2232
55.	-1.7906	32.5910	26.2221


CART9206.DAT
SIGMA-THETA
25.0 25.5 26.0 26.5 27.0 27.5
SALINITY (PPT)
32.0 32.5 33.0 33.5 34.0 34.5
TEMP (DEG. C)
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5
PRESS (DB)
0 20 40 60 80 100 120 140 160 180
T
S
σθ

Station #9214 on March 17, 1992

Raw data file: cart9207.dat

decibars	temp	salinity	sigmatheta
5.	-0.5281	20.7129	16.5895
10.	0.9251	24.3192	19.4687
15.	0.7535	25.1523	20.1433
20.	0.5675	25.5642	20.4803
25.	0.2349	25.8514	20.7212


CART9207.DAT
SIGMA-THETA
2.0 7.0 12.0 17.0 22.0
SALINITY (PPT)
2.0 6.0 10.0 14.0 18.0 22.0 26.0 30.0 34.0
TEMP (DEG. C)
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5
PRESS (DB)
0 20 40 60 80 100 120 140 160 180
T_f
T
S
σ_θ